FOOD INDUSTRIES

The Journal Devoted to the Problems of the Food Manufacturer

Volume 4.....Established 1928—McGraw-Hill Publishing Company, Inc.....Number 5

NEW YORK, MAY, 1932

•

Laurence V. Burton, Editor

Efficient Heat Application Necessary to Plant Economy

HEAT enters into every branch of food manufacture in some way or other. In unit operations such as cooking, baking, evaporating, or pasteurizing; in cleaning or sterilizing; or in both, heat is a universal tool of the food processing industries.

• BECAUSE of the large expenditures for heat, its better application presents opportunities for considerable savings. This is particularly true in these days of low prices and consequent necessity for lowered costs. Unfortunately, however, many food processors still carry on wasteful heating practices handed down from other days when waste elimination was not so vital.

• CONSIDER canning. Exhaust boxes, blanchers, open cookers have wasted many millions of B.t.u. for the canner and eaten heavily into his bank account. Great clouds of steam issuing from the processing room have too often been accepted as a necessary evil. Measurements made in a California cannery show that this waste often reaches alarming size, although automatic control would reduce it to negligible proportions.

• STEAM LINES and processing equipment without heat insulation are also a source of much loss, although many food manufacturers believe that the cost of insulation is too high. They realize that heat is lost, but guess that the losses amount to less than the cost of covering. However, calculations of such losses, made in many plants, indicate that this guess is wrong and that insulation, at least for pipes and retorts, does pay.

• HEAT from the sun is generally regarded as free heat, yet lowered yield and quality sometimes make solar heat a more expensive means of dehydration than the combustion of

oil or gas. This dehydration process requires far more heat per pound of product than does canning, but nevertheless its efficient operation receives even less attention.

• IN DEHYDRATION, the usual medium of heat transfer is air, a gas of extraordinarily low heating capacity or specific heat. It must therefore be circulated with great rapidity and forced into intimate contact with products to be dried. Former practice involved a single passage of the heated air through the dehydrator. Today the practice is entirely different, for we now know that hot air in this service will lose its temperature of effective dehydrating long before it becomes saturated with moisture. Therefore, efficiency of heat application can be greatly increased here by recirculating most of the air and replacing with fresh air only enough to keep the escaping air near to the saturation point. The nearer it is to saturation the higher is the heat utilization efficiency.

• ONE method of heat application economy that has been successfully adopted by some plants and might serve well in many others is the byproduct generation of power. There are several ways in which this is done, the simplest being the generation of all steam for the plant at some fairly high pressure—say 300 to 500 lb. per square inch—and the passing of all this steam through a turbine. Such steam as is needed for process work is then extracted from the turbine at the required pressure, the remaining steam going on to the condenser. This results in the generation of all, or part, of the electricity needed by the plant at a cost for steam but slightly in excess of the cost of generating the process steam requirements alone. There are several other methods of byproduct power generation suited to various plant conditions. All serve to lower heating costs through credits for power.

• IN SEVERAL important food industries, temperature control is vital. The difference between the necessary temperature for milk pasteurization and the temperature that produces a slightly cooked flavor and variable cream line is small. Fruit syrups, juices, and beverages require certain minimum temperatures of pasteurization, yet slightly higher temperatures irreparably injure their flavors. The death temperatures of spoilage organisms and the "scorch line" of certain canned vegetables are very close together, and retorting temperatures must be carefully watched. In these cases efficiency in the use of heat is of less importance than accurate control of processing temperatures.

• AS A WAY to effect operating economies and to produce better products, heat conservation, heat control and precise heat application offer to every food manufacturer a field that needs most careful scrutiny. The methods described elsewhere in this issue of FOOD INDUSTRIES illustrate correct applications of scientific and engineering common sense.

Editorial Advisory Board,
FOOD INDUSTRIES.

What Heat-Transfer Theory Tells in the Food Plant

A major problem in nearly all food-preparation processes is the heating or cooling of the materials at various points in the operation. Whether it be the pasteurization of milk, sterilization of canned goods, concentration of juices, cooling of liquors, freezing of ice cream, or any of the countless other thermal changes, a knowledge of the heat transfer involved is essential for design and best operation.

By ALLAN P. COLBURN
Chemical Engineer
Wilmington, Del.

THERE are so many different types of apparatus available for cooling or heating that it usually is difficult to decide on which one to install. When changing a process or increasing the scale of operations, just what features of the heat-exchange equipment must be considered, and how a given apparatus can be made to transfer a greater quantity of heat, are questions that can be solved readily if the basic principles of heat transfer are understood.

Heat-transfer problems can be divided into two general classes: First, cases where there is a steady flow of heat; that is, where there is no variation of temperature at a given point in an apparatus with time; and second, unsteady state, or "batch" heating or cooling.

Steady State—For the steady flow of heat in one direction through a homogeneous solid, the following equation applies:

$$\frac{q}{\theta} = \frac{k}{b} A (t_2 - t_1) \qquad (1)$$

where q is the number of B.t.u. which will flow across A sq.ft. of surface in θ hours, k is the average thermal conductivity of the solid expressed as the number of B.t.u. which will flow in one hour through 1 sq.ft. for 1 deg. F. temperature difference per foot, and t_2 and t_1 are the temperatures on the two ends of the solid of length b ft. Thus to calculate the rate of heat flow under certain temperature conditions, it is necessary only to know the thermal conductivity of the solid, values of which can be found in any engineers' handbook.

A special case for flow of heat through a solid in more than one direction is an annulus, such as the insulation on a pipe. In this case the following equation should be used:

$$\frac{q}{\theta} = \frac{2k (t_2 - t_1) L}{2.3 \log \frac{D_o}{D_i}} \qquad (2)$$

where L is the length of pipe, and D_o and D_i are the outside and inside diameters, respectively, of the lagging. It is interesting to note from Equation 2 that the rate of heat flow through an annulus is dependent only on the ratio of outside to inside diameters, and not on the actual values, so that the same quantity of heat will be lost from a ½-in. pipe lagged with 2-in. outside diameter pipe covering as from a 2-in. pipe lagged with 8-in. covering of the same material. A chart is given by Zeiner[3] for determining the optimum thickness of pipe covering in terms of the relative costs of heat and insulation.

Where heat flows from a hot fluid to a cold one through a metal wall, it has long been known that laws of pure conduction of heat through the fluid do not usually apply, due to convection currents or turbulence effects. For that reason an arbitrary method of expressing the rate of heat transfer has been adopted in terms of heat-transfer coefficients. Thus the rate of heat transfer from one fluid to another is expressed:

$$\frac{q}{\theta} = U A \Delta t_m \qquad (3)$$

where U is the over-all heat-transfer coefficient in B.t.u. per hour per square foot per deg. F. temperature difference, and Δt_m is the mean temperature difference in deg. F. It was early shown that since U varied with the properties of both the heating and the cooling fluids, the rational method of treatment was to consider the resistances to heat flow of the heating and cooling fluids and of the metal wall as resistances in series, and to evaluate these separately as functions of the particular factors which affect each one. As the same quantity of heat flows through each of these, at a given point the following equation holds:

$$\frac{q}{\theta} = h_2 A_2 (t_2 - t_o) = \frac{k}{b} A_w (t_o - t_i) = h_1 A_1 (t_i - t_1) \qquad (4)$$

where h_2 and h_1 are the separate coefficients, usually called "film" coefficients, t_o and t_i are the temperatures on the outside and inside surfaces of the metal wall, and t_2 and t_1 are the temperatures of the hot and cold fluids. The over-all coefficient is then related to the film coefficients as follows:

$$\frac{1}{UA} = \frac{1}{h_2 A_2} + \frac{b}{k A_w} + \frac{1}{h_1 A_1} \qquad (5)$$

where A_2 and A_1 are the outside and inside areas, A_w is the average area of the metal wall, and A is the area used in Equation 3. The area A can be taken as identical to any of the other values.

An example of the application of Equation 5 is as follows: Assume steam is condensing on the outside of a standard ¾-in. pipe through which cooling water is flowing. I.D. = 0.82 in., O.D. = 1.05 in., thickness = 0.115 in. or 0.0096 ft., k = 30, assume condensing film coefficient, h_2, is 2,000, and the water film coefficient, h_1, is 1,100. For a length of pipe of 10 ft. the outside area, A_2, is $\frac{1.05 \times \pi \times 10}{12}$ = 2.75 sq.ft., the inside area, A_1, is $\frac{0.82 \times \pi \times 10}{12}$ = 2.15 sq.ft., and the mean area is 2.45 sq.ft. Substituting in Equation 5 gives:

$$\frac{1}{UA} = \frac{1}{2{,}000 \times 2.75} + \frac{0.0096}{33 \times 2.45} + \frac{1}{1{,}100 \times 2.15} = 0.00185.$$

Thus UA = 1,380, and if A is based on the inside area of the pipe, U = 1,380/2.15 = 645 B.t.u. per hour per square foot per deg. F.

Equation 5 should be applied whenever there are not experimental values of U available for the particular apparatus considered. By predicting the film coefficients separately, in terms of the operating conditions affecting each, and computing the over-all coefficient from these values, a more reliable design can be made than by merely guessing at the over-all coefficient.

The mean temperature difference to be used in Equation 3 usually is equal to the logarithmic mean of the temperature differences between the hot and cold fluids at the two ends of the apparatus. Thus,

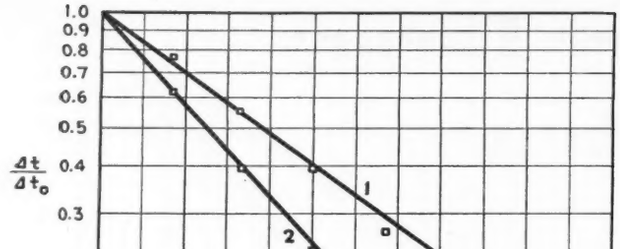


Fig. 1 — Temperature-time relationships for cooling chocolate (from data of Huggins); No. 1, without scrapers; No. 2, with scrapers

$$\Delta t_m = \frac{\Delta t_1 - \Delta t_2}{2.3 \log \frac{\Delta t_1}{\Delta t_2}} \qquad (6)$$

where Δt_1 and Δt_2 are the temperature differences at the two ends of the exchanger, Δt_1 being the larger value. Where the ratio of Δt_1 to Δt_2 is less than 2, the arithmetic mean can be used with an error of less than 4 per cent. The logarithmic mean temperature difference was originally derived on the assumptions that the heat transfer coefficient and specific heat are constant, and there is no change in the amount of material flowing through the exchanger. However, it can reliably be used, even if the heat-transfer coefficient and specific heat vary, by using the means of these values at the two ends of the exchanger.

The hot and cold fluids usually should be passed countercurrent to each other, as this will give the greatest possible heat exchange between them. In some special cases where it is necessary to keep the temperature of the metal wall down or to obtain extremely rapid cooling on the hot end, parallel flow is used.

Unsteady State or "Batch" Heat Transfer—This case differs from steady state, because temperature at any point is a function of time. Thus in the heating or cooling of liquids or plastics in kettles, heating of canned goods, or the heating and cooling of solids, the problem is to produce a certain temperature change of the material in a given time.

For heating or cooling of materials in kettles where no freezing or evaporation takes place, the following general equation applies:

$$\frac{t_1 - t_2}{\Delta t_m} = \frac{U A \theta}{W c} \qquad (7)$$

where t_1 and t_2 are the temperatures in deg. F. of the material at the start and finish of the process, Δt_m is the logarithmic mean of the differences in temperature between the heating and cooling mediums at the start and finish, U is the over-all heat-transfer coefficient in B.t.u. per hour per sq.ft. per deg. F., A is the heat transfer area in square feet, θ is the time in hours, W is the weight of the charge in pounds, and c is the specific heat of the charge. If the jacket or coil temperature does not vary with time, as is the usual case, the temperature change can be conveniently expressed:

$$\log \frac{\Delta t}{\Delta t_o} = \frac{U A \theta}{2.3 W c} \qquad (8)$$

where Δt_o is the difference in temperature between the heating and cooling mediums at the start of the process, and Δt is the difference at time θ. Thus the operation can be readily represented graphically on semi-log paper, with θ as abscissas on the arithmetic scale, and $\frac{\Delta t}{\Delta t_o}$ as ordinates on the log scale; the slope will be equal to $-\frac{U A}{2.3 W c}$. Such a chart is shown by Fig. 1. By inspection of Equation 8 or a graph, as suggested, the effect on the temperature of the charge of changing the amount of heat-transfer surface, the weight of the charge, or the heat-transfer coefficient, are apparent. Values of the over-all heat-transfer coefficient, U, should be computed from film coefficients by use of Equation 5 whenever these can be predicted.

The time-temperature relationships in the heating or cooling of solids have received a wealth of theoretical study from mathematicians and physicists. As the characteristics of heating and cooling vary with every shape and with the temperature function and heat-transfer coefficient in the surrounding medium, a separate solution is desirable for each case. The method of applying the Fourier law of heat conduction to general cases is shown mathematically by Ingersoll and Zobel.[10]

Due to the complexity of the usual solutions for cases of unsteady state, Gurney and Lurie[8] worked out several graphs which provide a very convenient method of obtaining the time-temperature relations in the heating or cooling of solids of simple shapes such as spheres, cylinders, and "slabs"—rectangular solids whose length and breadth are great with respect to the thickness in the direction the heat is flowing. These graphs permit the determination of the temperature difference between the surrounding medium and any point in the solid at a given time from the original temperature difference and the properties of the solid and surrounding medium.

From the Gurney and Lurie plots, the temperature of the center point of the solid can be expressed approximately as follows:

$$\log \frac{\Delta t}{\Delta t_o} = -\text{const.} \frac{k}{\rho c} \frac{\theta}{R^2} \qquad (9)$$

where Δt is the difference in temperature between the surrounding medium and the center point of the solid after a time of θ hours, Δt_o is the difference in temperature at the start, k is the thermal conductivity of the solid in B.t.u. per hour per square foot per deg. F. per foot, ρ is the density of the solid in pounds per cubic foot, c is the specific heat of the solid, and R is a dimension of the solid—which is the radius of the cylinder or one-half the thickness of the slab. The group $\frac{k}{\rho c}$ is known as the thermal diffusivity of the material. Approximate values of the constant in Equation 9 are given by Table I.

Table I—Approximate Values of the Constant in Equation 9

$\frac{kR}{h}$	0	0.5	1	2
Cylinder.....	2	1	0.6	0.35
Slab.....	1	0.5	0.3	0.18

Note — h is the heat-transfer coefficient between the surrounding medium and the solid, in B.t.u. per hour per square foot per deg. F.

It can be seen from Equation 9 that if the heat-transfer coefficient is very large so that $\frac{kR}{h}$ is practically equal to 0, the time necessary to cool a solid varies as the square of the radius or thickness. As many food materials are made up largely of water, values of $\frac{k}{\rho c}$ for these foods will be essentially equal to the value for water, which is 0.0052 (feet² per hour) at 40 deg. F. and 0.0061 at 140 deg. F. It should be noted that Equation 9 holds only if there is no change of state of the solid undergoing temperature change.

Unfortunately, there has not been a complete work in English on equations for heat-transfer coefficients up to the present. However, a series of papers on heat transmission by W. J. King,[12] now running in *Mechanical Engineering*, is giving an excellent picture of the present status of heat-transfer information. Several convenient alignment charts for predicting film coefficients for gases-in-tubes, gases-across-tubes, free convection of gases and liquids, and condensation are being presented by Chilton, Colburn, Genereaux, and Vernon at the June, 1932, meeting of the Process Industries Committee of the American Society of Mechanical Engineers. These papers should supply data for predicting film coefficients for the usual cases of fluids such as air, water, and oils, whose physical properties are quite well known, in conventional types

of heat exchangers. A few equations for predicting film coefficients follow:

For water in tubes in turbulent flow:

$$h = 180\ (1 + 0.01\ t)\ \frac{u^{0.8}}{D^{0.2}} \qquad (10)$$

For water in free convection:

$$h = 0.45\ \Delta t^{1/3} t \qquad (11)$$

where t is the water temperature in deg. F., u is the water velocity in feet per second, D is the diameter of the tube in inches, and Δt is the temperature difference between the surface and water in deg. F. For condensing steam containing no non-condensible gas, coefficients around 2,000 are obtained on horizontal pipes, and 1,500 on vertical. For condensing steam in the presence of non-condensible gas, data are given by Colburn and Hougen.[7] An approximate equation for cases of more than 2 per cent air and low vapor velocities is:

$$h = \frac{3{,}000}{\text{per cent of air}} \qquad (12)$$

Thus 10 per cent of air reduces the condensing steam coefficient to about 300.

For heating and cooling of food materials, there is often no way of predicting the separate film coefficients, and special types of apparatus are often used which complicate the calculation of the heat transfer. Changes of state in the material, such as freezing, melting, or evaporating, also must be considered.

Surface Coolers—In a popular type of heat-exchange apparatus commonly used for cooling, hot milk or other liquid drips down over vertical rows of horizontal pipes through which cooling water flows in series. If a velocity of from 3 to 5 ft. per second is maintained through the pipe, high heat-transfer coefficients may be obtained.

Possibly the best tests on surface coolers have been made by Van der Ploeg.[20] He determined surface film heat-transfer coefficients for water by measuring water temperatures and surface temperatures of the pipes in the cooler. His results can be expressed by the equation:

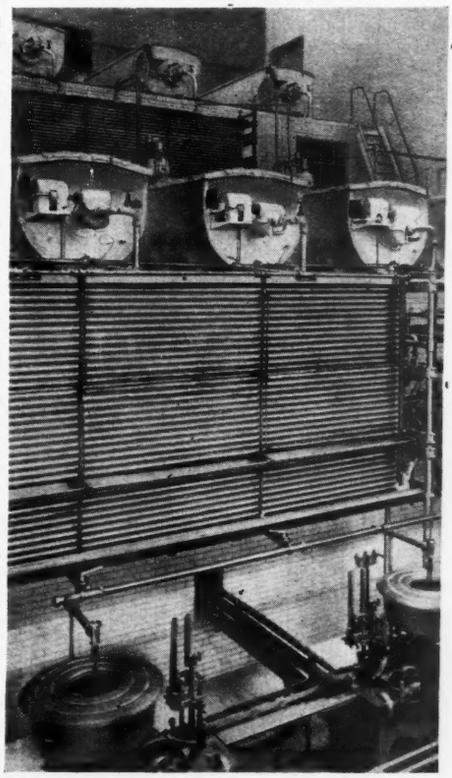
$$h = 60\ V^{0.25}\ (1 + 0.01t) \qquad (13)$$

where h is the film coefficient between the dripping water and the pipe in B.t.u. per hour per square foot per deg. F., V is the pounds of water per hour per foot length of the top pipe, and t is the average water temperature in deg. F. It can be seen from Equations 10 and 13 that for water at 70 deg. F. flowing through 1-in. tubes at 5 ft. per second, and a dripping rate of 600 lb. per hour per foot at 120 deg. F., the two film coefficients will be 655 and 1,110, respectively, giving an over-all heat-transfer coefficient of 410 (neglecting the difference in inside and outside areas). Such a high value probably would never be obtained, due to the formation of scale and the collection of solid material on the tubes. To take care of this resistance, a scale or rust coefficient of from 300 to 800 should be included. Thus if a scale coefficient of 600 had been included with the above film coefficients, the predicted over-all would be 245, more likely to be near values obtained in practice.

Bowen[3] reports a test on cooling 3,255 lb. of milk per hour in a surface cooler used as a regenerator to preheat fresh milk inside the tubes; an over-all coefficient of 186 B.t.u. per hour per square foot per deg. F. was obtained with a velocity in the tubes of only 1 ft. per second. Experiments on cooling milk at the Oregon Experiment Station are described by Price.[16] Rabe and Bussen[17] describe the cooling of a liquid extract, wort, by dripping it over a "Baudelot" or surface cooler of a series of horizontal coils. On the basis of 6 sq.ft. per barrel of wort per hour, the wort was cooled to 70 deg. F. with tap water at 60 deg. F. from which an over-all transfer coefficient of about 130 is calculated. These authors remark that when the surface cooler is used vertically, the results are about twice as good. Surface coolers have been used for cooling ice cream mixes. According to Bayer,[4] for cooling 1,000 lb. of mix per hour to 50 deg. F., 20 sq.ft. of surface is necessary. The mix is cooled with water down to 80 deg. F. and then with brine. An over-all coefficient of about 60 was obtained in the water cooled section.

Jacketed Vessels—When jacketed vessels are used as evaporators, the heat-transfer process is essentially one of steady state operation, so that the special treatment for "batch" cases is not used except for the warming-up period. After the liquid begins to boil, it maintains a fairly constant temperature and the rate of evaporation depends upon the rate of heat transfer from the jacket or coils to the liquid. Bowen reports a test on a 6-ft. vacuum pan for evaporating milk at 24 in. of vacuum by use of 2.5 lb. steam, in which an over-all heat-transfer coefficient of 539 was obtained—typical of the high values obtained in evaporating with a high temperature difference, which was in this case, about 80 deg. F.

Fig. 2—Milk pasteurizers and surface cooler at Chestnut Farms Dairy, Washington, D. C.



A large quantity of data on heat transfer in enamel-lined apparatus is given by Poste.[15] He concluded that the thickness of the enamel coating was the determining factor in the over-all coefficient of heat transfer. Because of the relatively large resistance of the enamel coating, the use of agitation had but a relatively small effect on the rate of heat transfer except for thick liquids such as tomato pulp. Based on Poste's data, the resistance of the enamel lining is approximately the equivalent of a film heat-transfer coefficient of 200. A summary of Poste's data is given in Table II.

Table II—Over-all Coefficient for Enamel-Lined Kettles

Material in Kettle	Material in Jacket	Agitation (r.p.m.)	U
a. Heating data on steel kettles			
Hot water	Steam	0	96
Hot water	Steam	408	120
Water	Hot water	Good	70
Boiling water	Steam	0	140
Hot milk	Steam	200	86
Cream	Steam	Good	90
Tomato pulp	Steam	0	90
Tomato pulp	Steam	Good	154
Boiling shredded pineapple	Steam	0	33
b. Cooling data on steel kettles			
Hot water	Cold water	Mild	43
Milk	Cold water	600	124
Milk	Brine	600	96
Cream	Cold water	Good	84
Oil	Oil	0	20
c. Heating data on cast-iron kettles			
Hot water	Steam	0	50

The use of glass-lined vacuum pans for preboiling and evaporating during the processing of cranberry sauce is described by Urann.[19]

Evaporators — Heat-transfer coefficients in evaporators may vary from 50 to 1,000, depending on the type of construction, characteristics of the liquid, and the temperature difference between the heating and evaporating fluids. In the sugar industry, multiple-effect evaporation is commonly used. Two very instructive series of experiments on the evaporation of sugar solutions have been made by Claassen[6] and by Kerr.[11] Claassen showed that the over-all heat-transfer coefficient decreased from 360 for water to 72 for concentrated solution in his apparatus, and that coefficients increased from 300 to 750 as the temperature difference was increased from 10 to 90 deg. F. Kerr made an extensive series of experiments and found that the coefficient decreased with the head of liquid over the heating surface, with density of the juice, and increased with increased temperature and increased temperature differences. A description of evaporators of from 3 to 6 effects used in concentrating sugar juice in Cuba is given by Young.[22] Two types are used, standard pans of about 2,500 cu.ft. capacity

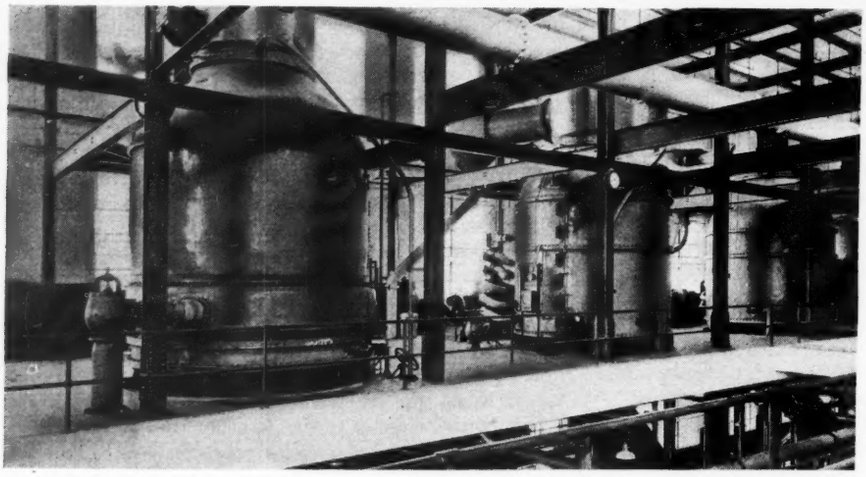


Fig. 3—In the design of sugar evaporators, heat-transfer studies play an important part

with the number of square feet of heating surface approximately equal to the rated capacity in cubic feet, and calandrias to utilize exhaust steam which are rated at about 1.5 sq.ft. per cubic foot of capacity. The typical performance of a single effect is given as follows: Steam supplied to calandria at 5-lb. gage; vacuum in pan, 27 in. of mercury; and boiling point of the juice, 115 deg. F. Area is 2,500 sq.ft. and evaporation rate is 50,000 lb. per hour. The over-all heat-transfer coefficient for these conditions is about 180.

The use of high vacuum evaporation for concentrating fruit juices and maintaining their flavors is described by Mackie[14] as applied to orange juice. The temperature is kept below 106 deg. F. by use of 29 in. of vacuum. An evaporation rate of 180 gal. per hour was obtained. Kroha[13] describes glass-lined vacuum evaporators for use on foods. Wischerath[21] discusses the use of a double-effect evaporation unit for the preparation of condensed and evaporated milk.

Batch Heating and Cooling—An example of the method of analyzing heat-transfer data in a jacketed kettle can be made from the test data of Huggins[9] on cooling chocolate. Huggins gives simple time-temperature curves for cooling 289 lb. of chocolate in a 50-gal. standard Dopp kettle equipped with a special "Style K-J" agitator with and without scrapers. According to the Dopp equipment catalog, a standard 50-gal. kettle has 8.4 sq.ft. of heating surface. Cooling water with an initial temperature of 68 deg. F. was used and the assumption has been made that the average temperature of the water in the jacket was 80 deg. F. Subtracting this value from the initial temperature of the chocolate and then from other temperatures read on Huggins' curves gave values of Δt_o and Δt used in constructing Fig. 1. The slopes of the two straight lines on Fig. 1 are —0.8 for the case without scrapers, and —1.2 for the case with scrapers. From Equation 8, the slope of the line for $\log \frac{\Delta t}{\Delta t_o}$ vs. time is equal to $-\frac{U A}{2.3 W c}$. From the above values of A and W, and an assumed specific heat of 0.5, the over-all heat-transfer coefficients obtained are, therefore, 32 without scrapers and 48 with scrapers. In going to a larger or smaller kettle, the time of cooling can be readily calculated from the new weight of charge and new heat-transfer area, if the coefficient of heat transfer can be assumed to be the same, possibly by having the same peripheral speed of the agitator.

Sterilization of Canned Food—The type of analysis to be made of thermal changes in canned food depends upon whether the can contains a fluid material or a plastic or solid mass. If the material is free to set up convection currents in the can when heated or cooled, the temperature-time relationships are best expressed by Equation 8, whereas if the material is incapable of convection currents, a modification of Equation 9 must be used. It has been customary to treat the cans of even liquids as solids and by use of pure conduction equations or a graphical method together with an equation similar to Equation 9, determine effective values of the diffusivity, $\frac{k}{\rho c}$. Since many canned food materials are mainly water, values of the true diffusivity must be approximately equal to the value for water. Thus Thompson[18] found by analyzing temperature-time curves that the diffusivity of squash was 0.0067 ft.^{2} per hour, which is only slightly greater than the value of 0.006 for water. The values for diffusivity found by Thompson for cans of water and fruits and vegetables packed in water solution, however, were much greater, showing the effect of convection currents. Typical values of apparent diffusivity found were 0.05 to 0.23 for asparagus, 0.04 to 0.2 for peas, 0.017 for strawberries, and from 0.05 to 0.10 for water, the value increasing with size of the can.

Since by this method of calculation, the value of apparent diffusivity is affected by the dimensions of the can as well as by the degree of convection currents, it is apparent that a more applicable method of correlating such data is in terms of the heat-transfer coefficient between the heating or cooling medium and the material in the can, as related by Equation 8. Thus the author has plotted Thompson's temperature-time data for heating asparagus in No. 2 cans in a water bath held at 212 deg. F. as $\log \frac{\Delta t}{\Delta t_o}$ vs. time, and from the slope of the line, the dimensions of the can, and the specific heat, over-all heat-transfer coefficient between water bath and can contents was calculated by Equation 8 to be 32 B.t.u. per hour per square foot per deg. F. As a film coefficient of around 130 would be expected on the outside of the can for these temperature conditions by Equation 11, the inside coefficient must be only about 43. For cooling the can in air, a temperature-time plot and Equation 8 resulted in a value of the over-all heat-transfer coefficient of only 1.3. Assuming that the inside coefficient would still be 43 would make the gas film coefficient 1.35.

On the basis of Thompson's results, and further information on the time necessary to destroy bacteria and spores at various temperatures, Ball[1] has worked out the mathematics of heating and cooling canned food. Later he[2] applied his formulas to the detailed solving of problems.

LITERATURE CITED

1. Ball, C. O., "Thermal Process Time for Canned Food." Bull. Nat. Research Council, Vol. 7, No. 37, 76 p. (1923).
2. Ball, C. O., "Mathematical Solution of Problems on Thermal Processing of Canned Foods." Univ. Cal. Pub. in Public Health, Vol. 1, No. 2, p. 15-245 (1928).
3. Zeiner, E. F., *Power 73*, 957-60 (1931).
4. Bayer, A. H., *Food Industries 3*, 182-3 (1931).
5. Bowen, J. T., *Agric. Engr. 11*, 27-32, 71-4 (1930).
6. Claassen, H., *Z. Ver. deut. Ing. 46*, 418 (1902).
7. Colburn, A. P., and Hougen, O. A., Univ. Wis., Eng. Exp. Sta. Series, Bull. No. 70 (1930).
8. Gurney, H. P., and Lurie, J., *Ind. Eng. Chem., 15*, 1170-2 (1923).
9. Huggins, F. E., *Ind. Eng. Chem. 23*, 749-52 (1931).
10. Ingersoll, L. F., and Zobel, O. J., "An Introduction to the Mathematical Theory of Heat Conduction." Ginn & Co., Boston (1913).
11. Kerr, E. W., *Mech. Eng. 55*, 731 (1913); *38*, 67, (1916).
12. King, W. J., *Mech. Eng. 54*, 190-4 (1932).
13. Kroha, G. F., *Chem. & Met. Eng. 30*, 721-2 (1924).
14. Mackie, A. M., *Food Industries 3*, 528-30 (1931).
15. Poste, E. P., *Ind. Eng. Chem. 16*, 463-4 (1924).
16. Price, F. E., *Agric. Eng. 11*, 33-7 (1930).
17. Rabe, F. W., and Bussen, R. W., *Food Industries 3*, 182-3 (1931).
18. Thompson, G. E., *Ind. Eng. Chem. 11*, 657-64 (1919).
19. Urann, M., *Food Industries 3*, 470-4 (1931).
20. Van der Ploeg, J., *A. ges. Kälte Ind. 37*, 63-6 (1930).
21. Wischerath, L. J., *Food Industries 1*, 111 (1928).
22. Young, A. M., *Chem. & Met. Eng. 30* 902-6 (1924).

Dairy Industry Depends Upon Steam for Heat Processing

By A. W. FARRALL
Director of Research Laboratory
The Douthitt Corporation, Chicago, Ill.
Formerly in Charge of Dairy Engineering
University of California

AMONG the specific processes in which the dairy industry utilizes heat, the most important are pasteurization, evaporation and condensing, drying, can and bottle washing, and sterilization of evaporated milk. Besides these, there are those of cheese cooking, and general plant heating and housekeeping.

The problem of applying heat to the proper point and in the correct quantity varies somewhat with the size of operation, the product, type of equipment to be used, and source of heat. There are certain general types of heating methods having wide application which must be considered in any heat-application problem. First is the method of transfer of heat directly from steam (live or exhaust) to the liquid. The use of this method is limited and in fact almost entirely obsolete at the present time because of danger of contaminating the product with impurities from the steam. It also has the disadvantage of diluting the product with water of condensation. The principal use of this method is in pasteurizing skim milk and buttermilk for feed purposes, also for "superheating" condensed milk and for certain other special purposes.

The second method involves the transfer of heat from a steam jacket through a metal wall to the product on the other side. A good example of this is a steam-jacketed hotwell or pasteurizer. The same principle is applied in certain types of tubular heaters which use steam as a heating medium. This type of apparatus is simple in construction and, provided a high velocity of the milk is maintained over the heating surface, gives goods results. The rate of heat transfer can be controlled quite easily by varying the pressure of the steam to suit the conditions. Uniform and complete removal of the condensate from the heating chamber is very important. Usually a trap is employed if the chamber or coil is under pressure while a simple "U" tube or "goose neck" overflow is satisfactory, and better, if there is no pressure on the chamber.

Such heating equipment is subject to formation of deposits of coagulated milk or milk stone on the milk side of the heating surface, which interferes with the proper transfer of heat and makes cleaning difficult. The deposits are caused by precipitation or coagulation, usually due to excessive temperature of the heating surface, slow moving milk film, or a combination of both. The salt balance of the milk, as well as the pH value, also affects the ease with which deposits are formed. Rapid and uniform movement of milk over the heating surface, combined with control of the steam temperature, are best assurance of satisfactory results. Perhaps the most frequent cause of "burning on" with this type of heater is when an inexperienced operator attempts to bring the temperature of the milk up too quickly at the beginning of the day's operation. Overloading the heating surface without knowing it is very easy under these conditions.

Scale formation on the steam side of the heating surface also decreases efficiency of the heaters and should be removed at intervals. Oil films should be guarded against if exhaust steam is used.

The third type of heating apparatus employs a hot-water circulating unit in which steam is used for heating a small body of water to a predetermined temperature. The water is then circulated through the milk processing equipment by either a steam jet or motor driven pump. Equipment of this type has the advantage that an accurate control may be had over the final temperature of the milk and, furthermore, that the hot water may be kept at a temperature of only a few degrees above the maximum temperature to which the milk is to be heated. Such control removes most of the danger of the milk becoming overheated, even should its flow be interrupted for a few moments. This method makes use of a milk heater having a large amount of surface, which, combined with the rapid flow of heating medium, results in rapid heat transfer even with a slight temperature differential. "Burning on" of solids is almost entirely eliminated with this type of equipment, and the formation of milk

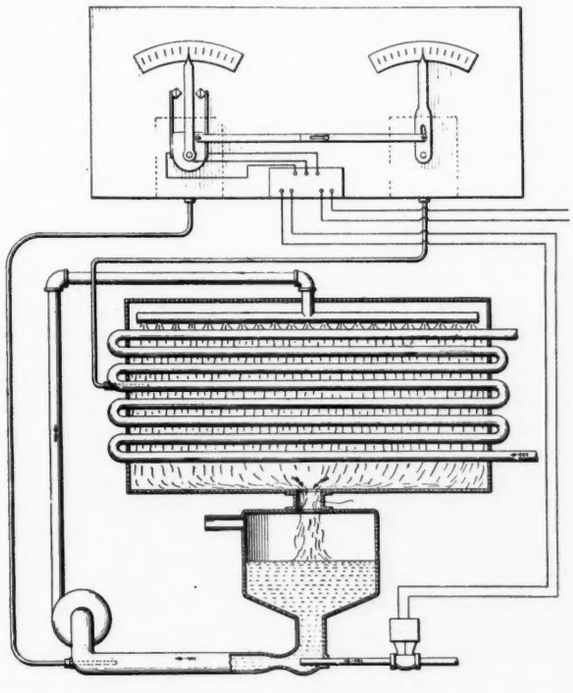


Fig. 1 — A complete milk-heating system equipped with a Godfrey "feeler" control for anticipating temperature changes in main body of milk

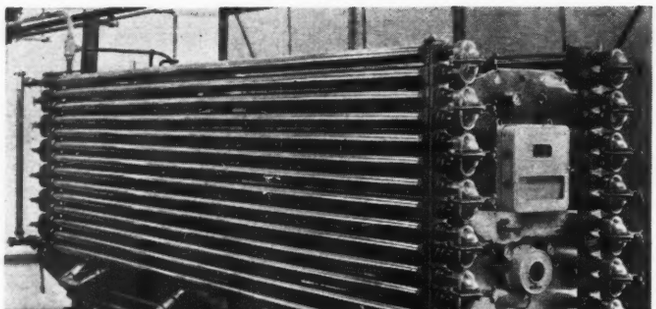


Fig. 2—For short-time pasteurizing in a hot-water continuous system, milk is heated to 160 deg. F. and held 15 seconds

stone deposits is kept at the very minimum. Temperature control of pasteurized milk is possible to within 0.1 deg. F. and the use of exhaust heat or other sources of hot water, especially for pasteurizing where temperatures of not over 145 deg. are needed, is quite feasible. Motor-driven pump circulation usually is preferred when accurate temperature control is necessary on continuous heaters.

Special mention should be made of the *spray* and *flooded* methods of applying hot water to the heating surface when water-circulating methods are used on vats. With the flooded method, the entire jacket is filled with the heating medium, while with the spray method, a perforated pipe directs the jets of hot water against the heating surface (side of a vat, for example), which causes a thin film of the liquid to run down to the bottom of the heating chamber, which is kept drained at all times. The effect of the spray method is to give a very rapid movement to the heating medium; also it reduces the volume of hot liquid next to the heating surface, thus making possible more accurate control of final temperature of the liquid being heated. Comparative tests of these methods by the writer showed much more rapid heat transfer by the spray method.

The fourth method of application of steam heat is used in "sterilizing" and consists of blowing a jet of steam under pressure against the equipment to be heated. This is a very wasteful method of applying heat and should not be used unless there is good reason.

For quick heating, it is best to use *wet* steam as the moisture present makes better contact with the surface which is to be sterilized, and is heavy enough to go to the spot to which it is directed. Dry steam often merely blows against the surface and is wafted away by air currents, leaving very little heat in the article against which the jet was directed. There are certain conditions, however, such as in the final steam treatment of cans in can washers, where the use of dry steam, even superheated steam, is best because it leaves less moisture on the surface of an already wet surface.

Consideration of heat application in the dairy industry should include a thorough discussion of the effects of heat upon the various products. Such a discussion would be so involved that there is not space for it in this article. However, it is information which every dairy engineer should have. He should know what *time* and *temperatures* milk products will withstand without injury under the conditions necessary for commercial operation. He should also know what is the best method of applying the heat to the product. It is sufficient here to state that prolonged exposure of milk to temperatures greater than 145 deg. F. materially affects the cream line on the bottle milk and that temperatures of 165 deg. or more are likely to cause some precipitation of milk salts and darken the color of the milk products. The matter of acidity and pH of milk products is known to affect their heat stability. Also the bacterial content and type of bacteria present have a bearing on the subject.

In applying heat to dairy products in general, good and bad effects must be balanced against each other. For instance, higher temperature pasteurization will perhaps give somewhat lower bacteria counts, but will so change the physical and chemical properties of milk that it cannot be used. Up to the present time the industry has found it desirable to use a temperature which is known to be bacteriologically safe, and be content with a slight effect on the physical and chemical properties.

Pasteurization has for its object the subjection of *every particle* of the milk to a certain predetermined temperature for a predetermined time. As previously mentioned, it is necessary to strike a balance between effectiveness of pasteurization and injury to the product. Care must be taken to make sure that every particle has sufficient heat treatment to render it safe, and yet not so much that factors such as the cream line, flavor, and color will be materially affected.

Much thought and inventive genius have been expended in the design of machinery for accomplishing this result. Many of the problems have centered around the proper movement of the liquid and the heating medium with respect to each other in order to insure uniform heating and proper control of temperatures. Godfrey in particular has worked out a very interesting type of control in which a "feeler" control anticipates the temperature changes in the main body of the liquid and thus gives a chance for the main control to act more quickly and with less disturbance than where ordinary methods are used.

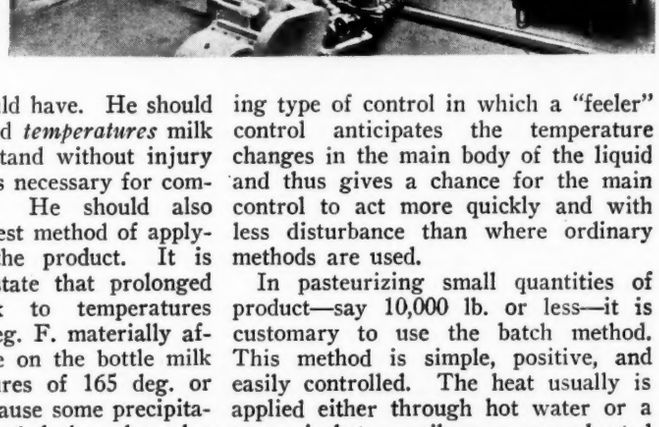


Fig. 3 — Pasteurizing unit with a 10,000 lb.-per-hour capacity. Milk is preheated to 145 deg. F. before going to holder pasteurizer. From the holder it is pumped through regenerator cooler to final cooler on left

In pasteurizing small quantities of product—say 10,000 lb. or less—it is customary to use the batch method. This method is simple, positive, and easily controlled. The heat usually is applied either through hot water or a steam jacket, a coil, or a spray-heated jacket. With this type of apparatus the temperature and time factors are so easily controlled that usually all that is necessary is a thermostat which will shut off the heating medium when the proper temperature has been obtained, or perhaps more frequently it is left to the operator to watch the temperature chart and manually cut off the heat supply at the proper time.

In large plants where considerable

volume of milk is processed, a continuous method of pasteurizing ordinarily is used. With this process the milk usually is preheated to the proper temperature by one or two stages in inclosed tubular heaters which have large heating surfaces and use a hot-water heating medium only a few degrees above the maximum temperature at which the milk is to be heated. From this preheater the milk passes through some sort of a holding device which maintains a pasteurizing temperature for the required length of time. The holding apparatus is of many different types; perhaps the simplest is merely an enlarged tube system through which the milk passes at such a rate that it requires the holding time to pass through. Another very common practice is to use a sort of pocket holder in which the milk is automatically fed into pockets or tanks where it remains for the holding time, and is automatically drawn off. The effect of this is a continuous flow of milk into and out of the apparatus as a whole.

After leaving the holder the milk is quickly cooled ready for bottling. In this cooling process there is often inserted a piece of equipment called the regenerator. The regenerator is a device through which the outgoing hot milk passes on one side of a tubular or flat heating surface and the incoming cold milk passes on the other side. It is a heat exchanger which allows the heat of the discharged milk to be absorbed by the incoming cold milk, thereby greatly decreasing the quantity of new heat which is needed in pasteurization process. A number of large plants are successfully making use of this idea, which enables them to decrease their cost of operation.

In general, it might be said that where a continuous pasteurizing process can be used for a period of one hour or more each day it is well to consider the installation of a regenerator. As a matter of operating information, it might be said that the regenerator under good conditions should warm the incoming cold milk from, say, 60 to 100 or 110 deg. F., making possible a very nice saving in heat.

The method of application of the heat to pasteurizing systems is of considerable importance. The modern tendency seems to be to have the steam, whether it be exhaust or live steam, enter a hot-water circulating system in which the temperature is automatically maintained to within a degree or two of a predetermined point. This hot water, then at a temperature only a few degrees above the temperature to which the milk is to be pasteurized, is circulated through the milk heater. There is practically no danger of "burning on" or overheating of the milk in the pasteurizer. This method calls for much more heating surface than the old-time methods in which live steam was placed directly against the heating surface, but the results obtained seem to justify the added expense. With this method of heating, care must be taken to move both the heating medium and milk at a good rate across the heating surfaces in order to speed up the rate of heat transfer. Many special types of pasteurizers and many types of heating apparatus are in use. Of these the spray vat is quite widely used for "batch pasteurization," whereas the short-time high-temperature continuous pasteurizer using a holding temperature of 160 deg. F. for 10 to 20 seconds is one of the latest developments which is very promising.

Evaporation of milk is nearly always carried out under vacuum, as the lower temperature of vacuum evaporation causes less injury to the milk, because of greater speed in evaporation and also because exhaust steam can be used to better advantage for heating. The usual temperature of the milk in the pan is about 140 deg. F. or less, depending upon the degree of vacuum maintained. The steam requirement for single-effect evaporation usually is somewhat less than 1.3 lb. of steam (100-lb. gage pressure) required per pound of water evaporated from the milk.

A great majority of the milk condensing and evaporating plants today use the single-effect evaporator, principally on account of the more sanitary type of construction and ease of cleaning. There is also the consideration that with the multiple-effect the milk must be subjected to higher temperatures than with the single-effect. Some progress has been made of late, however, in the application of multiple-effect evaporators to milk and buttermilk evaporation. The use of the double-effect is perhaps not justified in small plants, but offers good possibilities for saving in large plants which are operating more or less continuously. A good double-effect evaporator will use only slightly more than half as much steam to evaporate a certain amount of water as does a single-effect. Recent developments have also been made in the use of the recompressor in connection with single-effect evaporating pans. This apparatus, where it can be used, gives somewhat the same results as the multiple-effect evaporator.

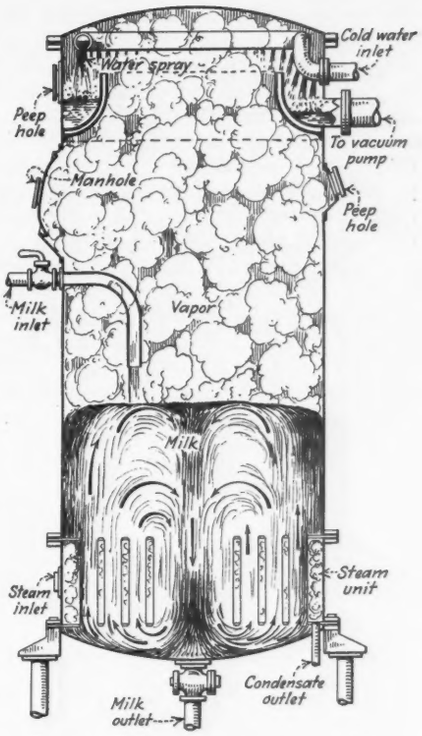
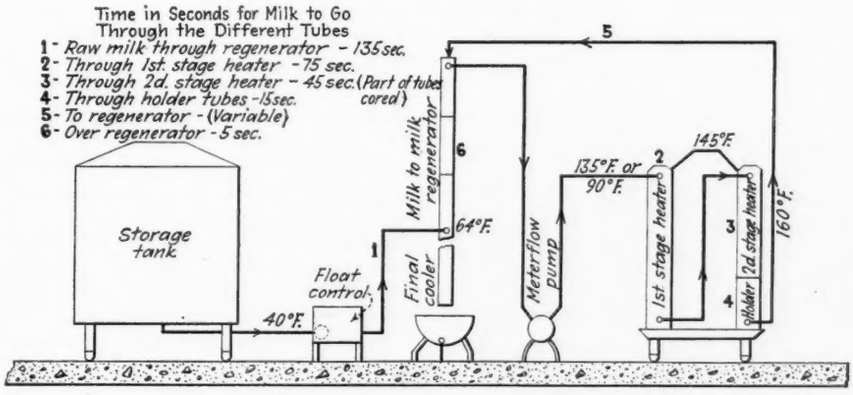


Fig. 5—In a modern single-effect milk evaporator the preheated milk begins to boil as soon as drawn into pan under vacuum

Because the temperature of the steam heating coils usually must be kept below 230 deg. F., exhaust steam is very successfully used in connection with evaporating apparatus. This steam can be fed into the steam main and either mixed with live steam or used entirely as a source of heat for the coils. However, care must be taken to remove oil and water; these impurities decrease the efficiency of the heating coils.

Milk drying requires large quantities of steam. This is quite evident when one considers that the average milk dryer uses from 1.1 to 1.7 lb. of steam per pound of water evaporated, also that it is not unusual for a milk dryer to evaporate from 4,000 to 10,000 lb. of water per hour. Some drying systems

Fig. 4—Short-time pasteurizing hookup for handling 15,000 lb. milk per hour


Time in Seconds for Milk to Go Through the Different Tubes
1- Raw milk through regenerator - 135 sec.
2- Through 1st. stage heater - 75 sec.
3- Through 2d. stage heater - 45 sec. (Part of tube cored)
4- Through holder tubes - 15 sec.
5- To regenerator - (Variable)
6- Over regenerator - 5 sec.
Storage tank
Float control
40°F.
Final cooler
64°F.
Milk to milk regenerator
Meter-flow pump
135°F. or 90°F.
1st stage heater
145°F.
2d stage heater
160°F.
Holder

use vacuum pans to precondense the milk before passing it to the dryer proper. Others pass the milk directly to the dryer and do all of the evaporating in the drying system. Most dryers use steam for preheating the liquid, in which case a tubular heater is employed. Some of them use the same type of heater for maintaining the heat of liquid during the precondensing or predrying period. The heat actually used in the final stages of spray drying usually is supplied to the air by means of steam coils. The heated air then transmits the heat to the liquid and carries off the vapors. Recirculation of air is successfully used in some types of spray dryers.

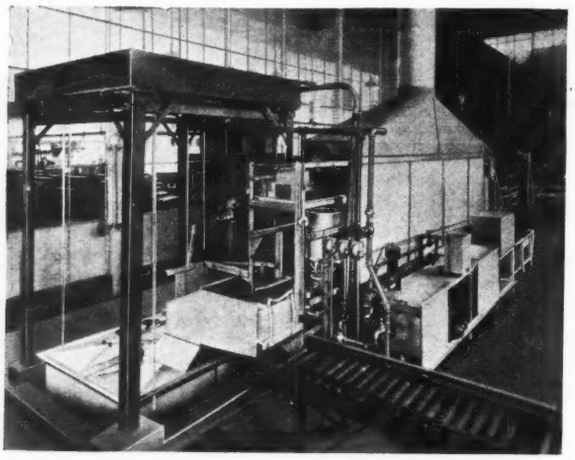


Fig. 6 — Can washers vary widely in type and quantity of steam required for operation. The straightway type operates automatically in a continuous manner

The usual type of liquid heaters employed in the drying equipment are of the barrel type, having multiple tubes through which the milk passes at high velocity. Hot water or steam surrounds the outside of the tubes and furnishes heat. With these heaters it is especially important to maintain high velocity of the milk in the tubes in order to prevent burning on of milk solids during an extended run. It is also important that the water of condensation be promptly and uniformly removed from the heaters in order to obtain uniform and rapid heat.

Transmitting heat to the air in the dryer usually is accomplished by means of copper finned tubes similar to those used on automobile radiators. This finned type of construction greatly increases the capacity of the tubes, makes them more sensitive to control of temperature, and decreases the amount of space required by the heating system. Dryers can often make use of exhaust steam, especially for preheating; for heating the liquid; and also, possibly, to do some of the air heating. The temperature of the air, however, must usually be so high that some live steam has to be used in the final stages of the air heating system in order to reach the proper temperature. Atmospheric type roller dryers and vacuum drum dryers can make use of exhaust steam very nicely, provided it can be maintained at a uniform pressure and temperature. Also, preheating of the milk increases the capacity of the dryer considerably. Uniform heating of the roll is necessary for satisfactory results.

According to data collected by the writer while at the University of California, the steam requirements of can and bottle washers may be very great. In plants on the Pacific Coast, can washers were found that drew over 72 boiler horsepower. In the same survey other types and makes of can washers were found which did equally good work and required less than one-third of that amount for the same number of cans washed. It is true that the washers using the smaller quantity of steam use somewhat more electricity than those of high steam consumption, but still the over-all cost was much less. Often the trouble is not so much with the can washer itself as it is with the way it is operated. The upkeep on the average can washer is high and there is much trouble with stoppage of jets, improperly working valves, valves which fail to shut off at the proper time, traps which do not work, and things of that nature. It is customary in many plants to put the cheapest man in charge of the can washer, which as a matter of fact is very poor economy. Not only is the importance of the can washing evidenced in the product turned out but the can washer itself is a machine which can waste a lot of money in a short while if it is not properly serviced and operated.

Bottle-washing equipment is subject to many of the same ills as can-washing equipment and many of the same principles are applied, especially in the smaller machines. There is one development in bottle washing which has been especially noteworthy, and that is the use of the soaker type bottle washer. Tests by the writer have shown this type of washer to be very economical in the use of steam and electricity, and there is no question but what it does a good job.

The principal point in the use of steam for washing and cleaning of either bottles or cans is to make sure that the heat is applied where it will do some good, rather than just be blown out into the atmosphere where most of it is wasted.

In the evaporated milk industry, where steam is used for sterilizing milk after it is canned, it has been found necessary to keep the cans under continuous motion during the heating process in order to obtain best results. In the Anderson-Barngrover Co. type of continuous sterilizer the cans of milk are fed into one end of the apparatus, augered through, and delivered on the other end after being held in contact with the heating medium, usually hot water, during practically the entire time of travel of the cans through the holder. In small plants sterilizing is done by a batch method in retorts under pressure. Again the principal object is to obtain thorough and uniform heating of the product for a certain predetermined period of time.

Heat control for these various processes is, in general, of two types. The first is a more or less rough type of control which will regulate to a degree, or to possibly one-quarter of a degree, of temperature desired. This type is used on the hot-water heating systems and apparatus of that nature. It usually is a direct acting throttling control in which a sensitive bulb filled with volatile liquid in contact with the liquid whose temperature is to be controlled operates a diaphragm valve controlling directly the flow of steam or other heating medium.

The second type of control is one which will regulate within perhaps 0.1 deg. F. and is used for regulating the actual temperature of milk which is being pasteurized. It is usually a more or less complicated apparatus, and, instead of using a volatile liquid to operate the control valve direct, it employs a third medium such as air or electricity to operate the control valve. The volatile liquid can be used to operate a very sensitive pilot valve which turns on or off the air or electricity used to operate the main regulating valve.

Proper control cannot be obtained without having a correct control apparatus for the job, nor can it be obtained with the correct apparatus unless the sensitive bulb and regulating valves are located properly with respect to liquid movements and temperatures. Elaborate time and temperature controls are available for special installations.

Steam Requirements of Can Washers*

	Cans per Hour Capacity	Cans per Hour (actual)	Pounds of Steam per Can	Boiler Hp. to Operate
A	360	360	5.44	66.00
B	385	385	1.84	23.60
B_1	385	140	5.19	24.20
C	240	240	2.17	17.45
D	600	495	4.58	72.75
E	300	264	5.59	47.08
F	600	403	3.64	43.17

*Taken from bulletin No. 433 University of California.

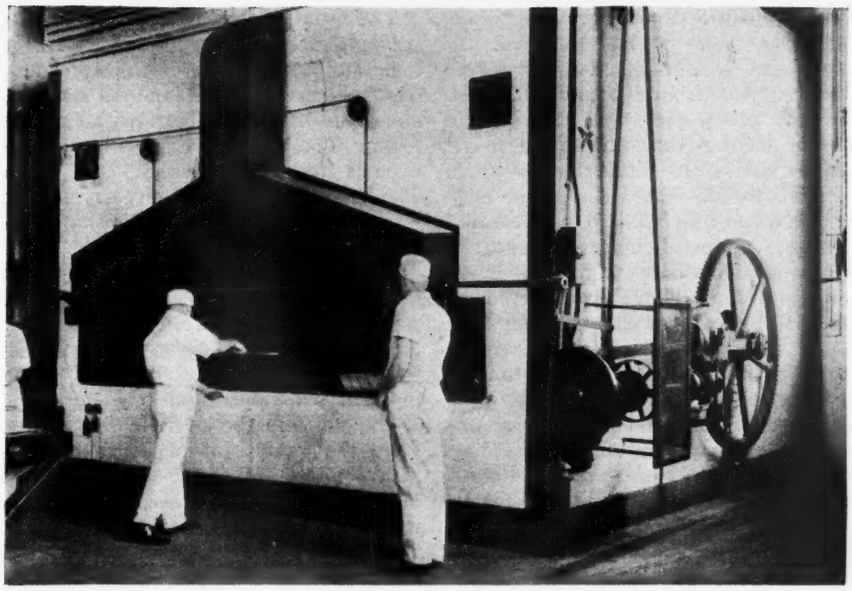


Fig. 1—Baking hearths of reel oven revolve through vertical plane. Rod across front of oven gives remote control to clutch for starting and stopping reel

By HARVEY O. MERCIER
Engineer in Charge of Development
and
I. HARRISON TROWBRIDGE
Baking Specialist
National Biscuit Co.,
New York, N. Y.

Oven Heating Characterizes Baking Industry

ALTHOUGH temperature regulation is an important factor in the production of bakery products from the storage of raw materials to the packaging of the finished goods, heat, on a quantity basis, finds application chiefly in the actual baking operations. When heat is used in the mixing, fermentation, and proofing operations its importance is measured more as an external influence upon yeast development in the sponge and dough than as a processing agent. In fact, during some portions of the year the optimum temperature range for yeast action, from 80 to 90 deg. F., is as likely to be obtained by actual cooling as by heating.

Sponge fermentation can be expected to give a rise in temperature of 12 to 18 deg. and doughs that of 2 to 4 deg. This heat of fermentation complicates control of the temperatures of sponges and doughs during proofing. As the proof room has a temperature of about 80 deg. F. and the sponge a temperature of about 75 deg. when it leaves the mixer, heat is actually absorbed during most of the sponge proofing period, whereas during the short proofing period of the dough, heat is being given off to the room.

In the proofing of cracker and biscuit doughs a thermostatically controlled cen-

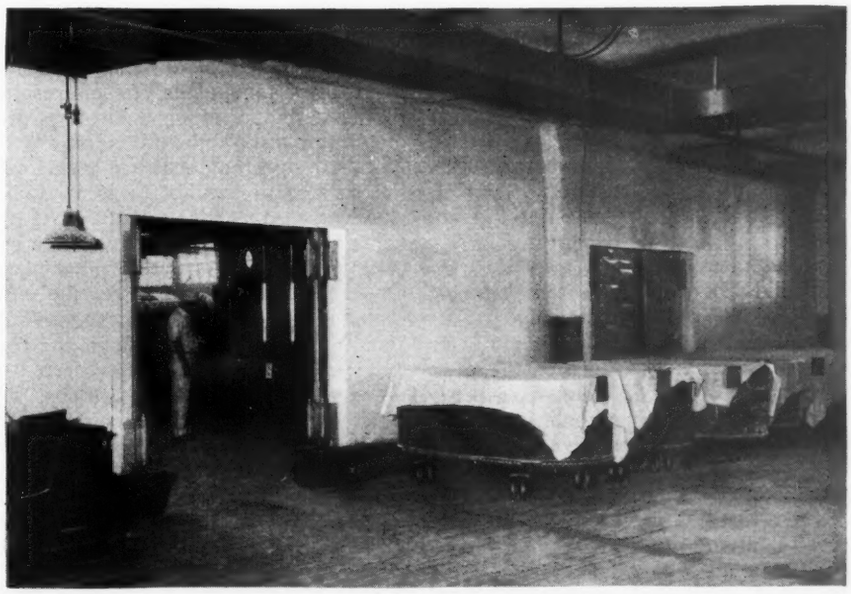


Fig. 2—Air conditioned for temperature and humidity is delivered to fermentation rooms from central unit. Mixing done near swinging doors to get benefit of regulated air conditions

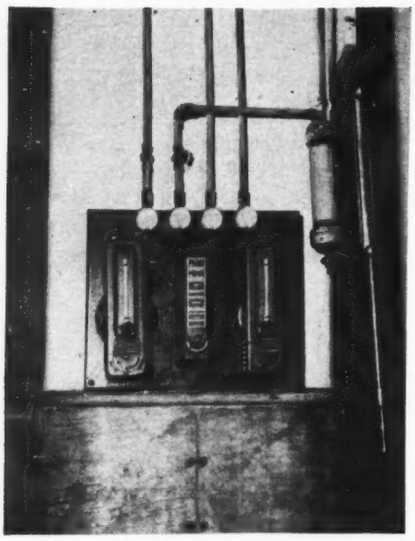


Fig. 3 — Controls in fermentation rooms automatically regulate temperature and humidity of air delivered. Hand thermometer for testing doughs hangs at right side

tral unit is the preferred means of obtaining air conditioned to a temperature of 80 deg. and a relative humidity of 70 per cent. The temperature at which sweet biscuit doughs are handled is very largely regulated by time and speed of mixing and by the temperature of the added liquids such as water, milk, sugar syrup, molasses, and the like, which are brought to the desired temperature before they are put into the mix. The range of temperatures for doughs of this type when completely mixed, varies from 65 to 120 deg. F., according to variety of biscuit.

In all instances the quantity of heat applied in fermentation and in baking, as well as the method of application, is as important in obtaining the differing characteristics of bakery products as are the changes in formula. During fermentation, in addition to the leavening action, the gluten of the flour is conditioned by the increase of acidity in sponge and dough and by the action of flour and yeast proteoses. During baking, moisture is evaporated; fermentation is stopped; gases are expanded to assist in leavening; starch grains are expanded and dextrinized; the gluten is fixed into a relatively stable mechanical structure; and, on the surface, the crust is formed by excessive drying, dextrinization of starch, and decomposition of sugar to give the familiar crust coloring.

Bread dough portions are relatively thick and require a longer baking period than do most bakery products. This period varies from 25 to 80 minutes or more and the temperature of the oven varies from 300 to 525 deg. F., depending upon the individual conditions. The familiar 20-oz. loaf usually is baked in about 40 minutes at an oven heat of approximately 410 deg. F. Sponge cracker sheets vary in thickness from $\frac{1}{16}$ to $\frac{1}{8}$ in. and are baked from $2\frac{1}{2}$ to 15 minutes at an oven temperature ranging from 400 to 675 deg. F. Sweet biscuit sheets are $\frac{3}{32}$ to $\frac{3}{16}$ in. thick and are baked from 4 to 18 minutes at temperatures varying from 400 to 575 deg. F. For soft cakes, pies, and pastries the time of baking varies from 20 to 70 minutes and oven temperatures range from 275 to 425 deg. F. Because eggs are freely used in this group the rapid hardening of the albumen when heat is applied accounts in part for the lower temperatures and longer baking time.

Baking operations call for heat as a definite processing factor and require that it be applied in a manner to give the desired product at a low unit cost. This means that good oven design for large-scale production requires close attention to several outstanding factors, such as: continuous baking, mechanical loading and unloading, exact control of temperatures, efficient fuel combustion and distribution of heat, effective insulation, control of the oven atmosphere, and means for applying steam to the product during baking. The five mechanical types more generally used for large production are the rotary, revolving reel, traveling tray, traveling tunnel, and traveling tier ovens. The tier type has been introduced within very recent years and promises wide adoption for large production requirements of certain types of goods; principally the sweet goods type.

The transition from the stationary hearth of the deck or cabinet type of oven to the moving hearth has resulted in the development of the rotary oven diagrammatically illustrated in Fig. 4. In this design the goods are peeled onto the surface of the hearth as it travels slowly past the oven mouth. As the name implies, the hearth moves in a circular motion and in a horizontal plane. One advantage obtained over the older types is the elimination of "hot" or "cold" spots, which results in the contents of the oven being subjected to practically the same heat conditions. The hearths are made either of soapstone or steel and vary in size from 7 to 18 ft. in diameter. They are sometimes built with double decks and with means provided for mechanically raising and lowering the decks to the level of the oven mouth.

The usual method of applying heat is through direct firing. Gas is used for fuel, although hearth ovens are made which burn solid fuel and oil as well, and some have been built with indirect firing. The principal application of this oven is for baking pies and soft cakes. The development of the rotary design was a step forward in facilitating loading and unloading by bringing the baked product close to the oven mouth through mechanical means. The construction, while usually of brick, in recent practice leans toward the fabricated steel framework with a sheet steel shell supporting block or blanket insulation.

Undoubtedly the oven in largest use from the standpoint of productive capacity is the revolving reel shown in Figs. 1 and 5. Reel ovens are mostly used for baking biscuit and crackers, although a large number of smaller sizes are used for baking bread. These small sizes usually are of the "portable" type. The reel-type oven differs from the rotary in that there are several hearths (or shelves, as we will refer to them here) moving past the oven mouth in a vertical plane, so that the baked product is brought still closer to the loading and unloading point than it is in the rotary. This results in a simplification of the handling problem, although it still falls short of a mechanical loading and unloading arrangement. A particular advantage of this oven is that almost any type of product can be satisfactorily baked in it.

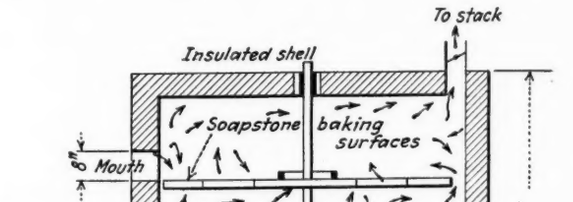


Fig. 4—Section through single hearth type of rotary baking oven. Source of heat under direct control of baker. Is not limited to gas for fuel

For baking sponge crackers a large quantity of heat must be quickly applied to the dough on entering the oven to obtain the necessary "spring." The heat, thus applied, generates a considerable quantity of steam by evaporating the moisture in the dough, which also assists in obtaining an effective "spring." The principal reservoir of heat for performing these two important functions in the baking process is the steel plate which constitutes the oven shelf. To store this heat in the shelf the reel is turned, after the fresh dough is placed on it, in a direction to take the shelf downward from the oven mouth toward the firebox. A hasty assumption may presume that this area is maintained at a higher tem-

perature than any other part of the oven, but when it is remembered that two processes are constantly working to reduce this temperature it will be evident that this area is very nearly, if not actually, the coolest part of the baking chamber. The first effect is that the relatively cool dough is being heated to oven temperature and moisture is being evaporated in considerable quantities; the cooling effect on the shelf results in a high differential between the temperature of it and the oven atmosphere with a corresponding high rate of heat input to the shelf. The second effect is that of the down draft of cold air entering the oven mouth and being accentuated by the movement of the shelves.

The reel is held stationary during the period of unloading and loading of the shelves at the oven mouth and the baking time is regulated by the baker through the manipulation of a clutch controlling the drive gear. As the shelf approaches the top of the oven in its circuit around the baking chamber the evaporation stage of the baking process is about completed. Furthermore, the spring of the goods has given them an irregular, bumpy bottom surface which has lost the intimate contact with the shelf plate possessed by the dough when first peeled onto it. Insulating air spaces replace this bond of shelf and dough, with the result that the conductivity losses from the plate are materially reduced. This condition permits the shelf to absorb considerable heat and, since the temperature is highest in this part of the oven, the shelf attains a correspondingly high temperature. When it reaches the oven mouth the baked crackers are removed and the fresh dough is deposited on the hot plate and the process repeated.

The dough is peeled onto the plates in separate sheets and, on account of the clearance between peels, which is increased by the shrinkage of the crackers in baking, the surface of the plate thus exposed attains a higher temperature than that portion which is giving up heat to the goods by conduction. This higher temperature brings about the application of more heat to the edge crackers than is received by those in the center of the sheet, which results in greater browning effect. Special baffling means are necessary to counteract this effect. Obviously the quantity of heat stored in the oven shelf is influenced by the mass of metal of which the plate is made up; the thickness varies between $\frac{1}{16}$ and $\frac{7}{32}$ in., depending on the type of dough and the character of the cracker.

Removal of steam from the baking chamber to prevent reabsorption of moisture by the goods before their withdrawal from the oven is important, and every effort is made to accomplish this result with a minimum of heat loss.

The total heat load for baking sponge crackers on this type of oven is approximately 2,500,000 B.t.u. per hour when baking on an average of 95 bbl. of flour per 9-hour day. This load is divided as: raising the temperature of the dough to that of the oven, 20 per cent; evaporating the moisture, 45 per cent; radiation losses, heating of excess air and products of combustion, and losses through oven openings, 35 per cent.

When baking sweet biscuit the heat requirements are somewhat lower, as the moisture content of the dough is less and the baking process requires a fairly even temperature during the whole period of the bake. For baking biscuit of this type the reel is turned in a direction opposite to that for sponge crackers. A study of the baking chamber arrangement with reference to the firebox indicates quite clearly that it is difficult to obtain positive control of the variable temperatures for the shelves as they are carried by the reel through different heat zones in the oven. For some types of sweet biscuit this is a disadvantage and has been overcome through the use of ovens of the traveling type which will be described later. In sweet biscuit baking and also for some types of sponge crackers, the dough pieces are deposited on flat pans of either the solid sheet metal type or open wire mesh construction. These pans are approximately 3 ft. long, 2 ft. wide, and in the case of the solid type, made from about 20-gage steel. The pans are placed either directly on the oven shelf or on a light skeleton framework arranged to support the pans approximately 4 in. above the surface of the shelf. These different methods are used, of course, for the purpose of controlling in a degree the rate of heat application to the bottom of the product being baked.

Although conduction, convection, and radiation are all used in transmitting heat to the product, it is evident that for sponge crackers the greater quantity absorbed is conducted from the oven shelf, while for sweet biscuit, with solid pans placed directly on the oven shelf, the conduction from the oven shelf is retarded, thus allowing a considerable quantity to be transmitted by convection through the oven atmosphere. In the case of open wire pans placed on skeleton framework the greatest quantity of heat is brought to the bottom of the product by convection and radiation.

The reel type of oven is not only practically universal in its ability to bake various types of doughs but it is also very flexible in that it is well adapted to the burning of solid fuels, gas, or oil, whichever is the most economical at the point of use. The method of firing is invariably direct and the products of combustion pass through the baking chamber. The oven temperature is controlled by the baker from the operating floor at the oven mouth. When solid fuels are used the firing is done before the baking period starts in the morning and at noon. Cables for operating the dampers are conveniently located for the baker. When burning oil or gas, valve extension rods are brought up through the floor for convenient regulation. The construction is of brick and the initial investment and maintenance is comparatively low for the productive capacity obtained.

Note: In an early issue Mr. Mercier will conclude this article with a discussion of traveling ovens.

THE EDITOR.

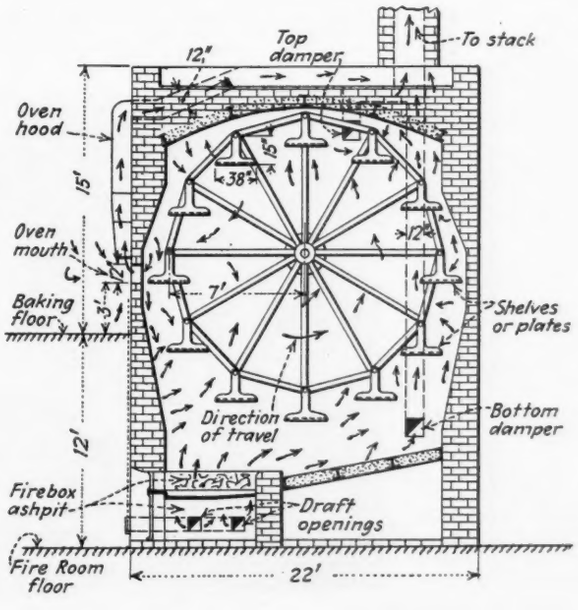


Fig. 5—Direction of rotation of revolving reel oven depends upon type of dough. Drafts and dampers under remote control of baker. Any kind of fuel may be used

Sterilizing the semi-fermented tea leaf in firing pans over charcoal. This method is used in Formosa for Oolong tea

Heat Governs the Flavor Of Tea and Coffee

By GEORGE F. MITCHELL
Former U. S. Supervising Tea Examiner
Tea Expert, Maxwell House Division
General Foods Corp.

THE tea plant, *Thea sinensis,* from which the young and tender leaves are plucked and utilized in the making of commercial tea, is an evergreen growing in its natural state to a height of from 15 to 30 ft. Under cultivation, it is restricted by pruning and plucking to a bush-like plant of from 1 to 4 feet.

Because of many variations in growth, botanists for years had recognized several distinct species. It is now agreed that only one species exists, but with many varieties. Any or all of these, however, might be used in producing the three primary kinds of tea; green, oolong, and black. Certain varieties are better suited for making one or more of the three different kinds. For instance, the Japanese leaf is better suited for the manufacturing of green tea; that grown in Formosa is better for oolong tea. In China, green, black, and oolong tea are made from the same variety grown in different localities. Leaves from the tea plants grown in the East Indies are especially suited for the making of black tea, although a limited quantity of green tea is made in Ceylon and India. Application of heat at the proper time makes it possible to produce from the same leaves the three primary kinds of tea.

When green tea is made, the first step after the leaves are plucked is to destroy the oxidizing properties called enzymes, and to prevent the oxidation of fermentation of the leaf by which color and flavor characteristic of black teas are produced. This oxidation or fermentation is prevented by heat, either by stirring the freshly plucked leaves in pans heated to 250 deg. F. over a charcoal fire, or by treating the leaves with live steam for a short length of time, as is done in Japan, Ceylon, and India.

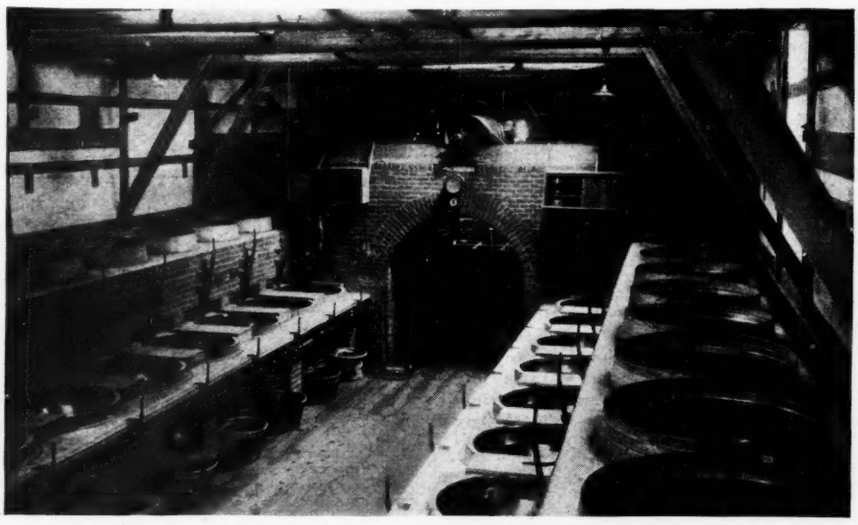
However, in experiments in manufacturing tea conducted by the U. S. Department of Agriculture in cooperation with Dr. Charles U. Shepard, of Summerville, S. C., the oxidizing properties in the freshly plucked leaves were destroyed by hot air in a horizontal rotary cylinder. This cylinder was about 12 ft. long and contained spiral flights on the inside which caused the leaves to fall several hundred times through its full diameter (20 in.) during their passage through the cylinder. When this cylinder was making 14 r.p.m., it required about 7 minutes for the leaves to pass from the automatic feeding doors, where they encountered a current of air at 550 deg. F. drawn through the cylinder by a fan, to the discharge end where the temperature of the air did not exceed 212 deg. F.

This treatment not only destroys the oxidizing properties in the leaf but also has the desirable effect of causing the leaves to become soft and flaccid. In this condition they were rolled, and after rolling were dried or "fired" for about 20 minutes in a current of air heated to about 200 deg. F.

In China and Japan, the drying of the leaves, after rolling, takes place either in hot pans or in firing baskets over charcoal fires. In Japan, pan-fired green teas are stirred mechanically in pans heated to about 220 deg. F. It requires about 27 minutes to dry 30 lb. of tea. Where baskets over charcoal fires are used, the temperature is kept very low to conserve the fine flavors of the tea. Although the leaves are stirred from time to time, from 6 to 9 hours is consumed in this drying process.

Oolong tea is first cured by permitting the process of oxidation partially to develop. The leaves are allowed to wither in the natural way either by spreading them out thinly on trays in the factory or in the sun, or by stirring them, as they do in Formosa, in large shallow baskets placed in the sun. After partial oxidation or fermentation has been accomplished, the oxidizing properties of the leaf are destroyed by stirring them in pans heated to about 250 deg. F. The leaves are then rolled, and after rolling are immediately fired in baskets over charcoal fires.

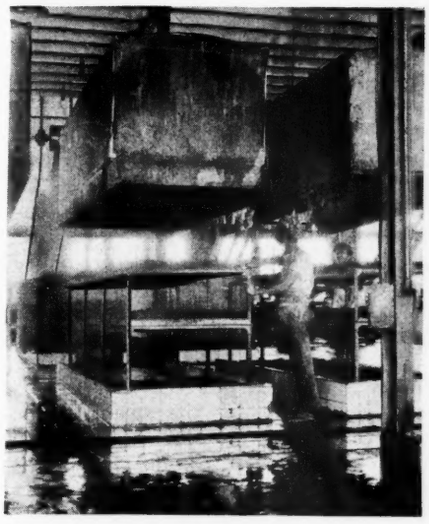
In curing black teas, there are four immediate steps; withering, rolling, fermenting, and drying. Withering, which is a preparatory step to rolling, results in the desired loss of water and produces a flaccid mechanical condition of the leaf. Withering is generally accomplished by spreading the leaf very thinly on trays or tats in the factory for from 18 to 24 hours. It is sometimes ac-



Firing and cooling pans for making green tea in Japan. The upper tier of pans is heated to about 220 deg. F. The tea is stirred mechanically

complished artificially by heating the leaves in withering machines in a current of air at a temperature of about 140 deg. F. for 45 to 50 minutes. The leaves normally contain about 75 per cent of water. During this process, they lose from 40 per cent to 45 per cent, leaving them ready for rolling.

During the process of rolling, whether it is accomplished by hand or machinery, the cells of the leaves are broken and the juices which contain the principles necessary for good tea are spread over the surface of the rolled leaf, where they are subsequently dried on, and can easily be taken in the solution by the hot water used in making the infusion.



Fermenting tables for making black tea. The wet canvas jacket above the tables is let down to raise the humidity

Rolling reduces the surface of the leaf, imparting to it the familiar twist of most commercial teas and thus helping to preserve the aroma. Although rolling is done by hand in China, and to some extent in Japan, in the East Indian tea countries, including Ceylon, India, Java and Sumatra, it is done by machines, requiring from 40 to 60 minutes. This operation determines to a great extent the strength of the tea, and also plays a part in preventing deterioration.

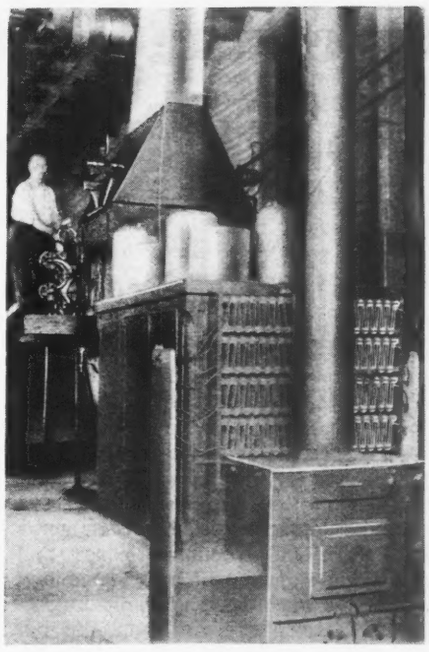
After rolling, the leaves are spread on tables or cement floors for from 2 to 6 hours to oxidize or ferment. The best results are obtained where the oxidizing room is kept as damp as possible. The finest flavors in East India black teas develop where the temperature in these oxidizing rooms is regulated from 75 to 84 deg. F. During fermentation, the leaf is changed from a dark green to a bright coppery color and the "leafy" odor is converted into a characteristic "fruity" one. When these characteristics appear, the fermentation is checked by drying in a current of hot air that enters the drying machine at 190 to 200 deg. F. The simplest form of these drying machines is an inclosed series of trays with movable bottoms on which the moist tea leaves are exposed to the blast of heated air forced up through the apparatus by powerful fans.

The oxidation or fermentation process in the case of China black teas differs from the East Indian method in that it is carried out at a higher temperature, by spreading the rolled leaves for a short time in the sun, or by making them into balls which are kept in a warm, moist temperature over night. This hot oxidation gives China teas an entirely different flavor and aroma from East Indian black teas.

Tea manufacturers differ as to the maximum safe temperature that may be used in drying tea, but my experience is that any temperature above 200 deg. F. causes a loss of flavor and aroma. This drying process is accomplished in about 20 minutes. The drying or firing machines are sometimes heated by wood, coal, coke, even by electricity, but generally by liquid fuel, such as crude oil.

In Ceylon, India, Java and Sumatra, the average cost of drying tea with liquid fuel is about ½c. per pound of dried tea. When wood fuel is used it is considerably less. This refers only to the amount of heat required in the final firing or drying of tea.

During the manufacture of tea, there is a loss in weight of about 75 per cent between the freshly plucked leaves and the finished tea. Tea properly fired contains from 3 to 5 per cent of moisture calculated on the dry leaf at the time the firing is completed. Although tea will not spoil or become moldy until the moisture content reaches more than 8 per cent, finished tea containing more than 5 per cent of moisture is likely to deteriorate by a slow process of oxidation.



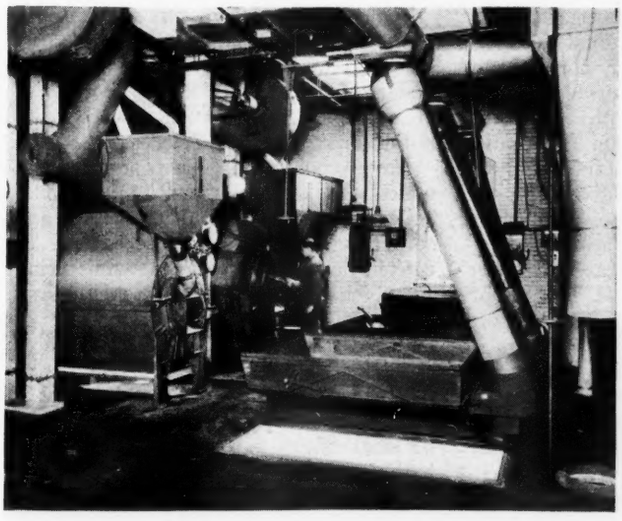
Either wood or electricity may be used to heat air for firing tea in this experimental dryer in South Carolina

Roasting of Coffee

Control of heat in coffee roasting determines definitely the development of flavors and aromas. It also determines, within certain limits, the amount of body, since a perfect fast roast ruptures the cells and the soluble extractive matter is made more available for extraction at the time of brewing. Although coffee can be roasted with such fuels as coal, coke, and more recently electricity, practically the universal method involves the use of gas.

In American the average temperature used is about 380 deg. F. and the average time is about 20 minutes. During this roasting process, the temperature in the roasting machine drops as soon as the green coffee is introduced into the roaster and then rises steadily until the roast is removed. For instance, a charge of 530 lb. of green coffee will pull the temperature down to about 180 deg. F. but then it steadily rises to 380 deg. F., and after the gas is turned off and the charge has been removed, the heat might even reach 400 deg. F.

A 530 lb. charge of green coffee will yield a finished roast of 445 lb. or show a loss of about 16 per cent in moisture. A roast of this size requires about 200,000 B.t.u., or 370 cu.ft. of gas. At a cost of 80c. per 1,000 cu.ft. this will amount to 30c. per roast.



Coffee roasters and cooling pans at one of the Maxwell House plants

Packing House Profits Depend On Efficient Use of Heat

By J. M. LENONE
Engineering Department
Wilson & Co.
Chicago, Ill.

ALTHOUGH the history of the technical development of meat packing has largely been regarded as a development of better refrigeration, there has been an equal and parallel development of heat technology which is frequently ignored or forgotten. Without heat, many of the by-products, on which the packing industry depends for a profit, could not be made; lard, oleo oil, stearine, and kindred products could not be prepared; hogs could not be economically dehaired; cured meats could not be smoked; summer sausage could not be cured; ham could not be boiled.

This list, however important it may be, nevertheless omits the greatest use of heat in the packing industry, which is to provide the enormous quantities of hot water that are absolutely necessary for proper cleaning of carcasses, offal, guts and, finally, the plant and equipment itself. A further use for heat in the meat packing house is that of live steam for deodorizing certain oils, a process which is accomplished by blowing high-temperature steam through the oil.

To obtain the requisite quantity of hot water, cold water is heated by steam. The heating effect is obtained by condensing steam in the water by means of open-type water heaters, allowing the hot water at from 180 to 210 deg. F. to accumulate in insulated hot wells having an aggregate storage capacity of 1,000,000 gal. In a normal working day the Chicago plant of Wilson & Co. will require 1,500,000 gal. of hot water for all the various technical uses to which it is put, aside from boiler feed.

From so large a hot-water demand, it may be inferred that the heat economy of the packing industry is closely tied up with power plant economy, a subject which will be discussed briefly later on. To produce 1 lb. of packing house products, ¾ gal. of hot water is required at an average temperature of 160 deg. F., which figures out 130 B.t.u. per pound of total products based on our production figures.

In pork operations are found the greatest demand for hot water. As soon as hogs are killed they must be scalded to permit easy dehairing and scraping. The carcass is dropped into a large tank of hot water, the temperature of which must be closely regulated between the limits of 138 and 142 deg. F., depending on the season of the year and condition of the hair. To go lower means that dehairing will be difficult, and to go higher will cause a very considerable loss of valuable gelatine from the skin of the hog. Regulation of the temperature is accomplished by automatic temperature controls which admit enough steam to keep the temperature up to the desired figure.

Washing carcasses does not require hot water because it has been found that high-pressure cold-water sprays employing pressures up to 400 lb. per square inch are as effective as hot water and have the added benefit of removing a part of the animal heat, thus aiding in chilling the carcass. However, for washing out casings (guts), hot water is indispensable. In this operation, temperatures are not critical, but water from the hot-water storage tank is used with automatic temperature regulation to keep the water as hot as possible for the operator to use without danger of scalding his hands.

The biggest use for hot water is in the daily cleaning of the equipment and plant. The former practice of heating cold water with steam by means of a mixing valve has been abandoned as uneconomical and has been superseded by hot water under very high pressures and a nozzle giving a flat or chisel-like spray that cuts the dirt and grease free. Pressure may be substituted for high temperatures much more cheaply and with greater effectiveness. Furthermore, a large number of the former mixing valves using steam for heating the water when in simultaneous operation imposed a surprisingly large sudden steam demand on the power plant and led to wasteful operation.

In the operation known as dry rendering of products is found the service demanding the highest steam temperature. Inasmuch as this operation involves only the introduction of saturated steam at about 80 lb. pressure into the jackets of the dry-rendering tanks or cookers, the jacket temperature is not critical and is maintained by the use of pressure-reducing valves on the mains serving the rendering departments. The temperature of the product is regulated by controlling the internal pressure of the tank from 40 lb. down to an actual vacuum. Steam for cooking lard in open-kettle rendering likewise is handled in much the same manner, but at lower temperatures.

Whether lard is to be steam-rendered or open-kettle-rendered is mostly a matter of color, flavor, or trade demands. The advantage of dry over wet rendering is that in the former, no "stick-water" is produced with its entailed expense of evaporating. The dry system is more economical in use of steam and is much easier to handle.

An important heat economy may be effected in this department by proper operation. In filling the tanks or kettles it frequently occurs that two or more are ready for the steam at the same time. Operators are cautioned to avoid starting two at once because it doubles the steam demand and tends to unbalance the steam and power load throughout that part of the plant. A large dry-rendering tank holds 8,500 lb., and to bring it up to proper temperature involves the condensation of 1,350 lb. of steam in about 30 minutes. This is equivalent to 80 boiler horsepower steam demand.

Evaporating "stick" or "stick water" (from the German word "stickstoff-wasser") is a multiple-effect evaporator operation and therefore requires only low-pressure steam. Normally 5 to 7½ lb. pressure is sufficient. The temperature of evaporation is controlled entirely by the vacuum in the last effect of the evaporator. The advantages of vacuum evaporation in this service over open kettles are lower temperature, much greater rapidity of evaporation under vacuum and, through the use of multiple effect, much lower steam requirement.

Ham cooking is an operation in which the ham, clamped in aluminum boilers or molds to hold it together and confer upon it a definite shape, is cooked in hot water, the temperature of which is a little below the boiling point. The problem here is one of both temperature control and heat economy. Heat is applied by means of live steam and the method of control is by thermostat, regulating the quantity of steam from the temperature of the bath.

In smoking cured meats, it is neces-

sary to bring the temperature of the smokehouse up to the desired point, which varies widely for different products. The heat is obtained from steam coils in the lower part of the house and the smoke is produced by burning sawdust, using gas burners to ignite it and regulating the air entering the fire pit so as to produce smoke. This is much more economical than the old method of producing both heat and smoke by the slow burning of wood.

Automatic temperature controllers regulate the quantity of steam to the heating coils so as to hold the temperature of the house at the right point. Heat economy is effected by keeping the smokehouse closed tightly as much as possible.

A large smokehouse is three, four, or five stories high. The upper part is tight, except for the ventilators, and the hot atmosphere is thus trapped in the upper part. The products on racks, attached to chain conveyors, circulate up and down through the hot smoke, while fans stir the gases constantly and maintain as nearly uniform conditions throughout as possible.

Air-conditioning is important in drying certain forms of sausage and cured meats. Here it is desired to dry with air at a temperature of 55 deg. F. and 72 per cent relative humidity. Steam at 7½ lb. pressure is suitable for this service. Automatic controls regulate the humidity and temperature of the air in the dry room.

House heating—the heating of buildings in winter—is the last big service for heat in packing houses. The steam used here is low-pressure steam used either in ordinary radiators, pipe coils, or unit heaters and is normally exhaust steam.

To discuss heat technology in packing house operation, and at the same time to omit a consideration of the power requirements, is to present a lopsided picture, if not an incorrect one. Anyone who is considering the larger problem of heat balance must consider the problem as a whole rather than focus attention on certain details, if a constructive approach is to be made that will result in the maximum possible economies. Accordingly, a brief review of the power-heat problem of the packing house is given at this point.

Packing House Heat Balance

Can other manufacturers tell where the heat is used in their plants?

	1000 B.t.u.
Heat Units in Steam	1000
Distribution by Services:	
Turbines	55
Compressors and pumps	27
Water Heating	342
Cooking and Processing	413
Remaining in Condensate	138
Radiation losses	25
	1000

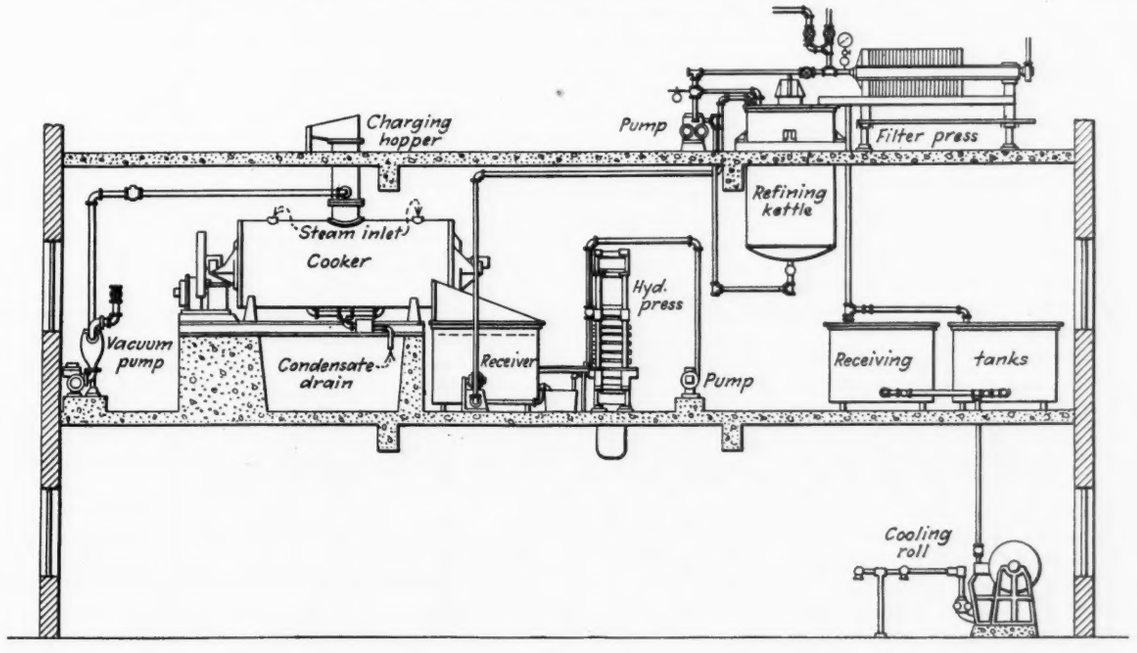
The total steam generated in a modern packing plant supplies two main demands: 33 per cent goes to the power house to drive power engines or prime movers, refrigerating machines, air compressors, and pumps; while 67 per cent is used for processing and building heating.

The first step in the production of steam is the boiler house. The selection of fuel is important and should be made on a basis of cost to produce steam with the equipment available. A fuel that has a low cost per ton may prove expensive in the cost of steam production. It must be remembered that it is potential heat that is being purchased in the fuel and it is the cost of the available heat and not the cost per unit of weight of the fuel that determines its real value in the plant. The design of boilers should be such that clean, dry steam is produced with radiation and stack-gas losses at a minimum, and enough grate area and furnace volume to burn the fuel completely.

The ideal method of using the steam is to put it through a turbine which will reduce the pressure to that of the various process requirements and at the same time generate the electric current needed to run the plant. The working of this method can best be shown by a practical example. In this case, 170,000 lb. of steam per hour goes to the turbine at 375 lb. gage pressure and 550 deg. F. temperature. This turbine operates a 3,500-kw. electric generator. Steam to the extent of 64,000 lb. per hour is bled from the turbine at 155 lb. pressure, and is used to operate the ammonia and air compressors, and the pumps, all of which exhaust their steam to water and building heating lines at 7½ lb. pressure. Another part of the steam—90,000 lb. per hour—is bled at 85 lb. pressure and goes to the rendering and cooking of products. The remainder of the steam, 16,000 lb. per hour, leaves the turbine exhaust at 7½ lb. pressure for low-temperature cooking and for heating purposes.

All of the electric current and power is thus being produced in the process of reducing part of the required steam from boiler pressure to house pressure,

Equipment for dry rendering of lard, showing location of steam inlets to cooker jacket and outlets from jacket to drain, also vacuum system, as laid out by Allbright-Nell Co.



and the balance of steam required for the house is supplied through pressure-reducing valves. This method produces the required power and process steam in proper quantities without waste and at the best efficiency. If they are utilized in the same way the economic cycle will be complete.

A study of the heat cycle helps to a realization of the relative importance of heat economy in its various uses. The steam leaving the boiler should contain at least 70 per cent of the heat put into the furnace as fuel. If this is not the case, then there is need for improvement in design or method of operating the boiler plant. Where the heat in the steam goes is shown in the accompanying table.

In heating water, the rather common practice of having small heaters or mixing valves scattered over the plant is a poor one, because they are both inefficient and wasteful of heat. The better practice is to employ one large heater or, if the plant is sufficiently large and spreads over considerable area, two heaters properly located with respect to departments needing hot water, with an hourly storage capacity sufficient to take care of peak demands for the entire plant. These large heaters act as a balance wheel on the entire system by absorbing large quantities of steam when the other demands for it are lessened, thus storing the surplus of heat in the water. When other demands increase, the water system takes less steam and draws on the stored heat in the hot water to keep the proper balance. Open-type heaters are best because they take both steam and condensate into the water system, eliminating the need for traps and drains and with no heat losses. If exhaust from engines or pumps is used, it should be passed through separators to remove oil from the steam before it goes to the heaters. The stored hot water should be maintained at a temperature above that of the highest required in various plant operations, and the water should go to the various uses through temperature-controlled mixing valves where the hot water mixes with cold water and the temperature is reduced to that required for the various purposes.

The tendency of operators to use steam at a pressure higher than is needed to get the temperature required for any particular process wastes heat and is very often the cause of poor quality or spoiled products because of burning or scorching. Steam at 5 lb. gage pressure has a temperature of 227 deg. F. and, therefore, is hot enough to use in any case where the temperature of product does not need to go over 212 deg. F. In cases where the temperature of the product must be greater than 212 deg. F., the pressure of steam used should be such that its temperature is not more than 20 deg. F. above that of the highest temperature of the product.

The often-heard declaration of the operating man that he cannot get results from low-pressure steam is, in many cases, true; but usually it is because of poor design of the apparatus or of the quality of the steam and not because either the temperature or the heat units of the low-pressure steam are not adequate. In order to get the advantage in economy from the use of low-pressure process steam, care must be exercised in the design of apparatus in which it is to be used.

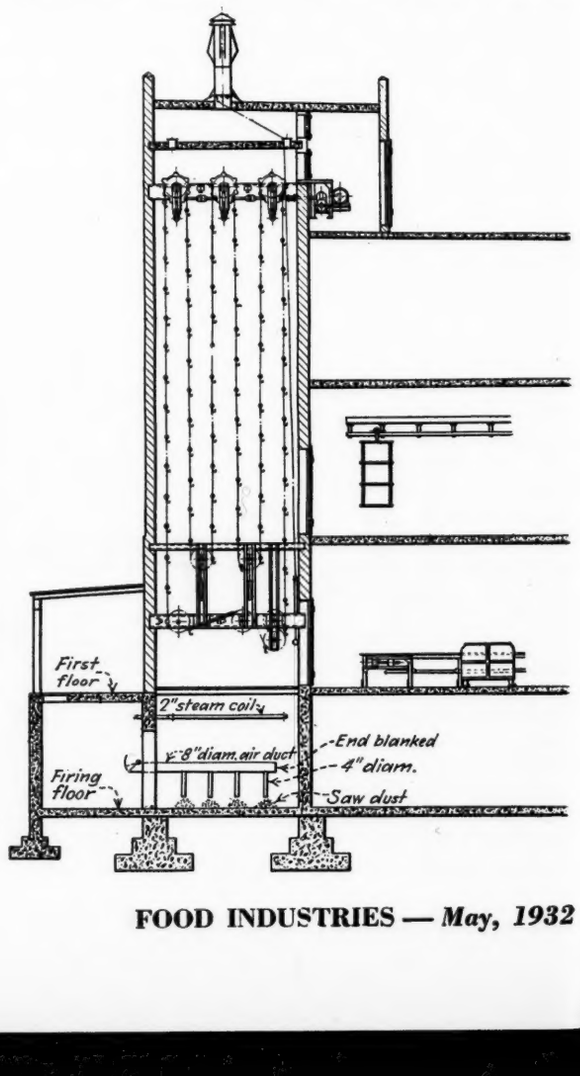
The heating surface, whether it is in the form of pipe coils or jackets, must be sufficient to get the requisite quantity of heat to the product at the transfer rate that practice has proved to be possible with the low-temperature differential between products and steam. The supply pipe must be of sufficient size to carry the volume of steam required to give the quantity of heat needed.

The very great importance of the following needs great emphasis. *Steam must not be allowed to simply "blow through" the coils or jackets, but must be trapped so that it is condensed before it escapes. When steam is cooling from 227 deg. F. to 212 deg. F., it gives off 6 heat units per pound, but steam at 227 deg. F. condensed to water at 212 deg. F. gives up 976 heat units per pound, which means that it will take 163 times as much steam, when not trapped or condensed, to give up the same quantity of heat to the product. This means a cost of $163 when not used correctly, equivalent to $1 when steam is properly used.* The drain line and trap must be of adequate size to keep the steam space free of water, because any of the space occupied by condensate is shut off to steam, and the surface is not doing its work of transferring heat to the product. The condensate should be returned to hot water system and not thrown away, because it still contains 13.8 per cent of the total heat in the steam, and wasting this is throwing away good money.

An important item, often overlooked, is that process steam should not be superheated, because dry steam surfaces are not efficient in heat transfer and, therefore, saturated steam or slightly wet steam gives the best results. Where the exhaust steam from turbines, or steam passed through reducing valves is used, it usually will be superheated, and should be passed through a de-superheater before going to heating surfaces. Steam at 50 lb. pressure reduced to 5 lb. pressure will have about 45 deg. F. of superheat and 100 lb. of this steam passed through a de-superheater will evaporate 2.28 lb. of water from 200 deg. F., making 102.28 lb. of steam leaving the de-superheater. In other words, a gain of 2.28 per cent is made while producing a more efficient heating medium.

There are a few processes in the packing industry where higher temperatures are necessary, but in most of the work, steam at 5 lb. gage pressure or less can be used to good advantage. Rendering is one of the processes that requires higher temperatures because it is necessary to break the fat cells by the generation of steam within them at a pressure that will cause them to burst. This requires a temperature of about 300 deg. F. and so requires process steam at about 80 to 85 lb. pressure. However, the same rules as to heating surface, supply and condensate lines hold good in the case of the higher pressures as in that of the lower pressures in order to obtain efficiency, and not use more steam at a higher temperature and pressure than will give proper results.

Conveyor-type smokehouse of Allbright-Nell design used by Wilson & Co. This smokehouse uses steam heating coils and a separate air supply, rather than the hot-air blast used in many installations of this conveyor type



Candy Making Requires a Wide Temperature Range

By W. TRESPER CLARKE
The Nunnally Co.
Atlanta, Ga.

Fig. 1—Cream cooker, cooler, and two beaters. Cooler is steamed out to prevent seeding by crystals from preceding batches. Batch in far beater is "creamed off"

THE thermal requirements of candy manufacture are as varied as the types of candies themselves, but, simple as these requirements may seem on the surface, there is much of interest and complexity for those whose concern is the intelligent production of satisfactory confections. Of primary interest to the manufacturer is the type and kind of heating each individual product requires.

Some hard candies and roasted nuts call for intense heat: 300 to 400 deg. F. At lower temperatures, 250 to 300 deg. F., come the syrup batches for nougats, and from 220 to 250 deg. F. are the syrup batches for fondants, caramels, gum-type candies, and some jellies. If we take the range slightly lower, from 215 to 220 deg. F., we include the syrups for crystallization work and making marshmallows. To drop any lower removes us from the actual cooking range, but we utilize temperatures of 170 to 200 deg. F. to remelt or soften caramels; 120 to 160 deg. F. to remelt fondants and maintain them in condition for the coating of centers. Around 70 to 110 deg. F. is the melting and processing range for chocolate, and from 40 to 70 deg. F. is the normal tempering and cooling range for candies and unfinished goods. Thus our thermal range takes us from 40 to 400 deg. F. or higher.

We transfer heat energy to our candies by the use of the open-flame, vacuum cooking in jacketed steam-pressure kettles, atmospheric steam cooking kettles, water jacketed kettles, and, in some cases where mild, uniform heating is needed, simple electric heating coils. For dehydrating purposes, as in the dry room where gum and jellies slowly give up their water content, warm dry air is the heat medium.

Steam under pressure in jacketed kettles is one of the most convenient and efficient means by which heating effects may be transferred to foods in process. The intensity of the heat required predetermines the pressure of the kettle. It is common practice to have steam at gage pressures ranging from 90 lb. per square inch, corresponding to 331 deg., up to 125 and 140 lb., corresponding to temperatures of 353 and 361 deg. F., respectively. The gage pressure of 140 lb. per square inch is the practical limit, but, due to increased economy and safety, the average of 110 lb. is general practice. Jacketed kettles of copper, Monel, stainless steel, or glass-lined kettles with suitable metallic coils are everywhere standard plant equipment.

In vacuum cookers for hard candy, where the pressure of the steam is high and gives high temperatures, the inside vacuum reduces the boiling point of the sugar syrup and permits the cooking of sugar in a minimum quantity of water at temperatures much lower than would be obtained at atmospheric pressures. Such reduction in temperature prevents decomposition of sugars into colored products which mar the attractiveness of the candy and prevents more serious results due to their continued formation. It is general practice among the better and larger manufacturers to employ the vacuum method for cooking hard candy, using vacuum pressures as high as 26 in. and 28 in., giving nearly water-white, viscous masses of fused sugars; figuratively alloys of sugar. The batches are weighed; the solids dissolved in water, 30 to 40 per cent of total batch, in a separate mixing kettle with steam jacket; and heated to boiling. The boiling syrup is drawn into the cooker through a siphon valve by a vacuum pump which subjects the vacuum cooker to a small suction head. When the proper quantity is admitted, the system is closed; steam is turned on; and the vacuum drawn. The condensate water is carried off and the evaporation continues until it leaves the dried, fused sugars in the desired working condition. The temperature at the end of cooking is seldom above 280 deg. F., but that depends on the vacuum pressure. At the end it is generally around 265 to 270 deg. F. when the vacuum is 25 in. These temperatures are well below the initial caramelization temperature of about 340 deg. F. for sucrose, at which point discoloration begins to proceed very rapidly. The heat may be supplied to the cooker through inside coils, always below the level of the cooking syrup, or by the ordinary steam jacket with steam at 100 to 110 lb. gage pressure.

Heat, as an agent, may be used to break down disaccharides into monosaccharides by the simple addition of a molecule of water and subsequent splitting. The production of these new products is dependent upon the intensity and duration of heat and is affected by other influential agents. This action is anticipated by the candy maker and is, in many instances, highly desirable to produce color and even flavor. In the presence of invert sugar, sucrose is rendered less soluble, but the solution is capable of holding a higher percentage of total sugars (sucrose, dextrose, and levulose) at ordinary temperatures than of sucrose alone.

The candy maker and chemist make use of this relation to build up the syrup density by decidedly more accurate and more easily controlled means. Such building up of total sugar solids in a syrup increases resistance to spoilage by molds and yeasts; raises viscosity and osmotic pressure; and makes for better keeping of cream centers, nougats, and marshmallows.

In practically all candy plants the majority of candies are of fondant cream base. The sugars, consisting of sucrose, invert sugar, corn syrup, or maltose syrup, are varied in their proportions by the individual manufacturer for his needs or to suit his working conditions and candy quality. Inversion due to heat is corrected for by the sucrose. When the batch has been weighed it is dissolved in water and cooked at a temperature of 240 to 250 deg. F., depending on the season, the ratio of sugars, the barometric pressure or altitude, and type of fondant desired. Practically all the heat added to the system is to control the crystalline structure of the mass. The solubility rises with temperature until all sugars are dissolved; then the excess water is driven off by more heat. Stirring and heating control the homogeneity of the syrup to the extent that at the end of cooking the temperature of the mass is considerably above that of the saturation for the sugars involved.

When the end temperature is reached, all heat must be removed as quickly as possible, because of the heat inversion reaction. This is accomplished by pumping the syrup, when the cooking is finished, into a cooler which has large circular plate coils through which cold water passes. When the cooling process passes the saturation point, no agitation or stirring must disturb the syrup until the temperature is nearly 65 deg. F. Hence the heat must be removed by conduction and radiation at the surface of the cooler. Cooling by convection becomes a factor because it implies motion of the syrup. Fortunately for the cream maker, the convective cooling is gradually cut to an almost negligible value, due to the rapid rise in viscosity and slowing up of voluntary motion attendant upon the changes in specific gravity.

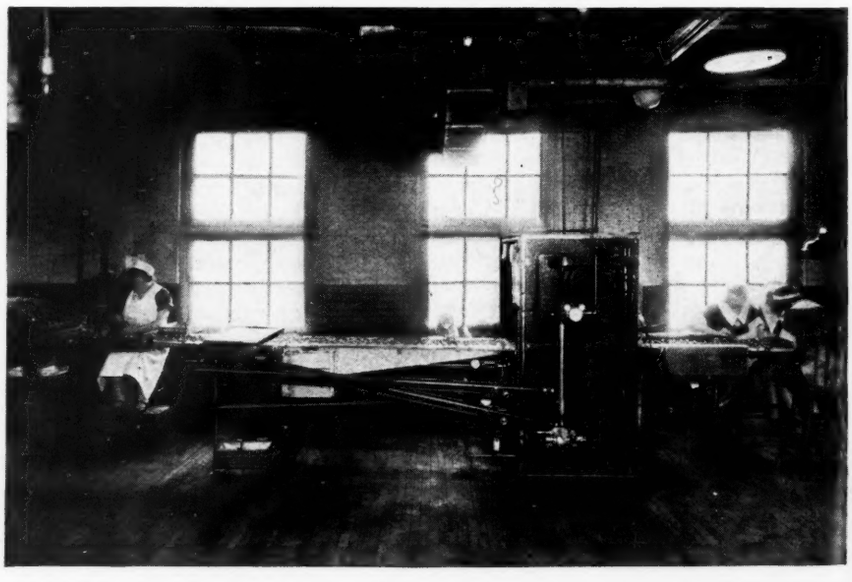
When cooling is completed, the viscous syrup, highly supersaturated with respect to sucrose and, in some cases, probably dextrose, is transferred to a revolving agitator, which works the syrup until minute crystals of the saturated solute begin to form and grow. These are broken and chipped off by the shearing force of the cream beater until millions and millions are forming and splitting every second. At this point some of the heat that was added to convert a sugar crystal into a solute is thrown off when the minute crystal is re-formed. This heat of crystallization is transferred to the air or to the base and sides of the revolving cream beater, which is water-jacketed and cooled by circulating cold water, as the mass passes the plows.

Another phase of cooking is dehydration in dry rooms at comparatively low temperatures. This process may be called "cooking by hot-air circulation" because precisely the same results are obtained, as far as composition is concerned, as if the goods had been cooked to high temperatures in the kettle. The results thus obtained are comparable with the drying of grapes by solar heat to form raisins. Candies dried in these rooms usually consist of starch gums and pastes containing much water, which, for practical convenience in casting into molds, has to be left in the body of the hot paste to give fluidity at the casting temperature. These candies are cast into preformed starch molds and then uniformly covered by starch to give the whole piece a uniform drying rate. The entry of the starch trays and contents into the dry room sets into operation the automatic heat control if addition of heat is required to raise their temperature to that of the surrounding air. This thermostat starts circulatory fans which pull cool air from the lower levels of the room upward through heating coils with fins to heat the air rapidly. This control also admits low-pressure (10 lb. per square inch) steam through the coils to supply heat to the air which is blown out through the room passing over each starch tray through the ventilating spaces between them. The starch which has been absorbing moisture from the incased centers is forced to give up its moisture to the hot air of low humidity. The moisture-laden warm air circulates toward the heaters again. To ultimately remove the moisture from the air it is the practice among larger manufacturers and those who have circulating cold water or brine available to insert a series of coils either in the base of the heating arrangement, on the wall opposite, or in some such location where the damp air will strike them and lose its moisture before being reheated.

It is not so advisable to dry too rapidly by striving to obtain the minimum relative humidity. If the cold water in the condensing coils be 45 deg. F. with a dry bulb of 140 deg. F., the depression of the wet bulb, which would still permit condensation on the coils, would be about 63 deg. F. and would correspond to a relative humidity of 3 per cent. Such drying causes crust formation on the surface of the centers and gives variable moisture contents running from surface toward the center. This is not desirable; therefore relative humidity is maintained in the neighborhood of 6 to 12 per cent. The room temperature, if kept at 140 deg. and made to maintain relative humidity in such a range, must give wet-bulb depressions of 60 to 53 deg., respectively, with corresponding dewpoints of 50 and 69 deg. As cold water of 55 deg. F. is commonly available in larger candy plants, efficient dehydrating facilities are possible.

Elsewhere in the plant, heat is used to produce changes in physical state to render conditions proper for processing. The most critical range in the temperature of most common confectionery materials is that wherein the change is from a liquid to a solid or vice versa. The importance of this range, unfortunately, is minimized by far too many candy makers. It is becoming better appreciated since chemists in the industry are studying more thoroughly the nature of materials at the point of change of state. In some cases—the caramel, for instance—there is no true melting point because it is not a true solid. The softening may be due to lowering of the viscosity simply

Fig. 2—Automatic enrober showing control dial between small pressure gages; heat interchanger is vertical cylinder above gear pump; air-conditioning duct overhead



through heat, but we must leave this to future investigators to find out just how simple a caramel may be in its colloid nature. In fondants, for which apparently there is good reason for classing as solids or semisolids, the addition of more heat raises the solubility of the sugars in the water comprising the syrup portion, with corresponding reduction in the solids. Such shifting in ratio reacts with what seems to be double force, for at the same time the solids in solution rise the viscosity drops and the remaining suspended solids have greater freedom of motion. Simple removal of heat brings about a reversal of this change.

In practice, the coating of candy centers with a bonbon fondant is simple. The changes in fluidity are brought about by subjecting small portions of the covering in a copper boiler to direct steam exhausted at 15 lb. per square inch on the bottom of the boiler or by setting the boiler in a hot-water-heating unit with a few turns of copper coil in the base which keep the water at about 150 deg. F. Its action is the same as that of a double boiler. Quick dipping with cooled centers causes a rapid set-up of the coating, which will hold a decorative design made by stringing a portion of the fondant on the center upward with the dipping fork and laying it down in artistic fashion over the top of the piece. In recent years there have been successful attempts to run centers through bonbon fondants on enrobers just as chocolate is run. This calls for precise temperature control and thorough knowledge of the sugar relations in the coating.

Probably the most exacting control of heat in the manufacture of any candy is that of chocolate coating in an enrober. The mechanical details are still far from perfect and will continue to hold the attention of the technologist. Chocolate is composed of sugar, cocoa-bean solids, and cocoa butters. Its state depends chiefly on the nature of the butters, because the fat is the constituent which changes state to an appreciable degree. Such change requires a transfer of latent heat. Further heating or cooling of the sugar and cocoa solids is checked until the latent heat factor is satisfied. It seems that such a control would be simple enough. Unfortunately, the butters do not have a definite melting point or point at which the latent heat may be transferred. Furthermore, they tend to supercool, form mutual solutions with each other, and offer difficulties which at present seem almost insurmountable. The chief factor in chocolate is the viscosity, which changes directly and sometimes indirectly proportional to the temperature. This is due to a series of events such as solidification of portions of higher melting fractions after supercooling and consequent direct increase in viscosity with temperature. These points, highly controversial in their nature, must be passed over with the merest mention, for the literature at present refers to this subject only vaguely and superficially.

In practice on mechanical enrobers a high degree of satisfaction has been obtained by the use of automatic thermostatic controls on the chocolate kettle and heat interchanger on the enrober. The chocolate is carefully tempered in outside kettles and then transferred to the enrober by pipes or hand pails. In the enrober the chocolate is agitated and circulated by pump from the small kettle up to the spillway which spreads it out in a continuous ribbon flow through a regulated opening. As the centers pass along under the ribbon each gets its share of coating and the excess is permitted to drain through the wire feed belt and pass back into circulation. The temperature of the chocolate during coating is kept as close to that at which the particular coating solidifies as the viscosity permits. Naturally with cool centers and surrounding air, unless the room is air-conditioned and regulated at the optimum, some of the chocolate heat will be lost to the centers or air (it could be just the reverse in a carelessly controlled enrobing room), with a reduction in fluidity.

To overcome this variation, a thermostat control, governed by the temperature in the chocolate main just before entering the spillway, operates double-acting valves which admit hot water or steam into the kettle jacket and heat interchanger. As the pump forces the chocolate through the interchanger additional heat is added to bring back the proper fluidity and some of the solidifying butter fractions are remelted. When the temperature goes to the other limit, the highest in the practical optimum range, the heat is cut off and slowly it drops back to the medium of the range. The best results such a control can give is always in cycles which unfortunately operate on a body which is right at the point of change of state, a point which in most other cases gives a sharp change in internal energy, viscosity, specific heat, and a host of other changes without change in temperature. In the chocolate mixture all of these factors are muddled up in a sensitive range which unfortunately again is the only one in which we can work. Probably in the not too distant future some controlling device, which we might term a "viscostat," will control the heat interchanges on a delicate scale in keeping with the nature of chocolate, or the addition of stabilizers, such as lecithin, will eliminate the most serious part of our troubles.

Essential to candy making are accurate temperature indicating devices. In other food industries, such as baking, it is possible to let temperatures vary over a wider scale than in the candy cooking process. Here the laws of solutions are supreme and one must toe the mark; cook to a definite degree or apply heat until certain definite conditions are obtained; then stop. The most common indicator used in cooking fudges, nougats, and taffy is the hand thermometer. It can be used to regulate the density, viscosity, rate of crystallization, and even the type of crystal. Industrial thermometers with extended protected bulb or the wall type, stationary registering type, are now taken as standard confectionery equipment even by the old-time candy maker who up to only a few years ago cooked to a "soft ball" or "hard ball" or "crack," as well as by the younger, modern cook. Even the forecast of the weather bureau is assuming a more important aspect in the more temperate zone where weather conditions vary over a wider range than in the Northern states. When the forecast indicates cooler weather the cooking temperatures for many of the retail types of candies are lowered by a degree or two so that they will not have a hard, dried-out consistency. The two types which are greatly affected are bonbon creams and caramels.

Fig. 3—Copper steam kettles in large candy plant. Two are of power stirring type. Beyond are two gas furnaces for open fire cooking

Drying Fruits and Vegetables With Sun or Heated Air

By EARL D. STEWART
Assistant Editor, Food Industries

FRUIT drying is an ancient industry, carried on in California since the Mission days. The rainless summers, and the dry, hot valleys of the state, where most of the fruit was and is grown, lend themselves to preservation by drying. In consequence, all the dried fruit produced was sun-dried at first, and the most of it still is; particularly the cut fruits: peaches, apricots, and pears. These ripen during the hot summer months and there is seldom any danger from damage by rain while the trays of fruit are in the open during the drying process. Raisins, apples, prunes, and figs must be harvested during the latter part of the summer and early fall, when there is always danger of showers, and it is among these fruits that drying by artificially heated dehydrators has made most progress.

The very name "dried fruit" indicates that the heat used in producing them is used for the evaporation of water. As the finished product must not be cooked, the heat must be applied at a low temperature. Minor uses of heat in producing dried fruits, including that required to keep lye dipping solutions hot and the heat evolved in sulphuring, are of small importance and rarely enter into calculations for capacity.

The quantity of water that must be evaporated varies with the kind of fruit. The "drying ratio"—that is, weight of fresh fruit to weight of dry product—averages 5:1 for apricots, peaches, and pears; 2½:1 for prunes; 1½:1 for figs; 4:1 for Thompson seedless grapes; 3:1 for Muscats; and 5:1 for apples.

Other considerations entering into any dehydrator calculations are quantity, velocity, temperature, and humidity of the air. Because of the low temperatures necessary, air is the only suitable means for carrying off the moisture evaporated from the fruit, and the quantity and velocity must be sufficient to dry the fruit thoroughly in the allotted time, usually 24 hours or less, so that fermentation or other undesirable changes are avoided. The relative humidity of the air used affects the heat and moisture carrying capacity. Air that is too dry causes "case-hardening."

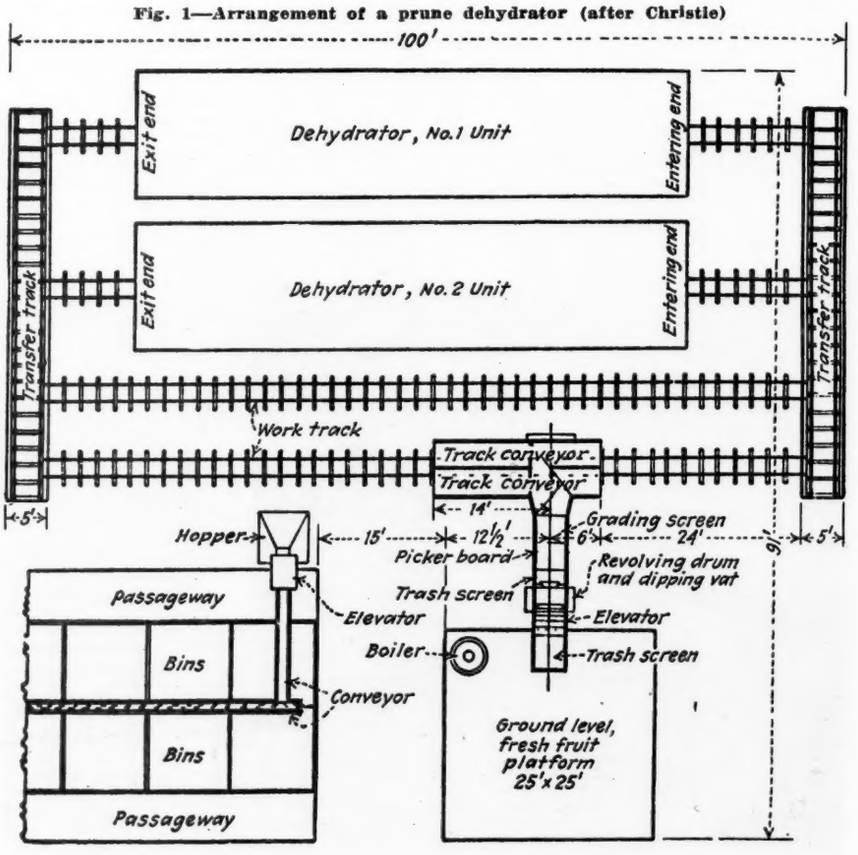
With the exception of the kiln dryer used for drying apples, most fruit dehydrators are of the tunnel type in which cars loaded with trays of fresh fruit are pushed in at one end and removed at the other. A fan blows heated air from a furnace over the trays. Recirculation of part of the cooled and moistened air is used on the more modern equipment.

It is customary to build the dryer tunnels in units, served by narrow-gage track leading from storage bins and to the remainder of the processing equipment. Such an arrangement is shown in Fig. 1, while Fig. 3 shows a typical dehydrating tunnel for prunes.

The heat requirements per unit of water evaporated from the fruit depend on the temperature of the fruit as put in and on the over-all thermal efficiency of the drying unit. Assuming that prunes at 60 deg. F. are put into the dehydrator and that they are raised to 150 deg. F., at which temperature the water is evaporated from them, sufficient heat to raise them through 90 deg. F., or roughly 90 B.t.u. per pound, will be required, plus about 1,010 B.t.u. to evaporate the water at 150 deg. F., making a total of 1,100 B.t.u. per pound of water evaporated. This figure will vary somewhat in either direction, depending on the temperature at which the prunes enter the dehydrator and the temperature at which the water is evaporated from them, but for purposes of calculation 1,100 B.t.u. per pound of water evaporated is sufficient.

As might be expected in a piece of equipment like a dehydrator, heat losses are high. The dehydrator itself must be heated up; there are losses of heat through cracks or insufficiently insulated spaces; the trucks and trays must be heated to the temperature of the dehydrator; and the hot prunes themselves carry considerable heat when they leave. Tests show that 45 per cent is a fair average figure for over-all thermal efficiency, so that the total heat requirements come to 1,100 divided by 0.45, or 2,444 B.t.u. per pound of water evaporated. This figure, 2,444 B.t.u.,

Fig. 1—Arrangement of a prune dehydrator (after Christie)



applies only to the fuel requirements for the dehydrator.

Since air is used both to convey heat to the fruit and to take away the moisture evaporated, it is also necessary to calculate the quantity of air required to perform the drying operation. It is necessary in making this calculation to know the temperature at which the dryer will be operated and also the relative humidity of the air used, which will, of course, vary from day to day and with the weather conditions. Assuming that air at 165 deg. F. and a relative humidity of 25 per cent is used, it is found on referring to tables of composition that a cubic foot of such air contains 0.0578 lb. of dry air and 0.0036 lb. of water, or a total of 0.0614 lb. of mixed air and water vapor. By multiplying the weight of dry air per cubic foot by its specific heat and the weight of water vapor per cubic foot by its specific heat, and adding the products, the number of B.t.u. per cubic foot of air mixture released when the temperature of the air drops 1 deg. F. is obtained. This amounts to 0.0155 B.t.u. per cubic foot of air at 165 deg. that is available when the temperature of such air drops 1 deg. F. If the total air temperature drop is 35 deg., the quantity of heat available will be 35 times 0.0155, or 0.5425 B.t.u. per cubic foot of air at 165 deg. F.

Dividing 1,100 B.t.u. the heat required to evaporate one pound of water at 150 deg. F. after heating it from 60 deg., by 0.5425 gives 2,028 as the number of cubic feet of air required per minute per pound of water to be evaporated. Since not all of the air will be available for evaporation, the actual figure is somewhat greater than this. By assuming an evaporating efficiency of 75 per cent for the heated air, we arrive at 2,704 cu.ft. of air per minute as the quantity required to evaporate each pound of water.

These two figures, the total heat requirement in B.t.u. per pound of water to be evaporated and the total air flow required in cubic feet per pound of water to be evaporated, are basic in designing a dehydrator. From the total heat requirement can be calculated the quantity of fuel necessary. By references to manufacturers' catalogs, the size of burner and type of furnace necessary to produce this heat requirement can be found. The total air necessary per pound of water evaporated leads to a determination of fan size, though here another factor, the velocity of air required, also enters. This is a little harder to estimate, since it depends somewhat on the construction of the dryer, type of trays used, and method of stacking them. Modern air-blast dehydrators call for air velocities between trays of about 500 lin.ft. per minute or over, usually around 600 and 700. Less than 500 lin. ft. causes slow drying and over 1,000 ft. is not economically practicable.

As an example in the use of these figures, assume that it is necessary to dehydrate 10 tons of fresh prunes per 24-hour day and that the drying ratio is $2\frac{1}{2}:1$. For every 20,000 lb. of prunes dried it will be necessary to evaporate 12,000 lb. water, or 500 lb. an hour. Using the figure previously derived for over-all fuel efficiency, 2,444 B.t.u. per pound of water, 500 lb. of water will require a total of 1,222,000 B.t.u. per hour. If fuel oil of 142,000 B.t.u. per gallon is used, this will necessitate burning 8.6 gal. of oil per hour or a burner of 9 gal. an hour capacity should be provided. A similar calculation, using the B.t.u. per 1,000 cu.ft. of the gas supply, will give the gas requirements.

Unless natural gas is used, the gaseous products of combustion probably will not be mixed with the air used to dry the fruit, so it becomes necessary to calculate the total surface area of furnace and flues that will be required to radiate this quantity of heat. As radiation varies so greatly with the type of furnace and flue, no exact figure for this can be given, but 400 to 500 sq.ft. is usual for a plant drying 10 tons of fruit in 24 hours.

Evaporation of 500 lb. of water an hour means 8.33 lb. a minute, and since a previous calculation shows that 2,704 cu.ft. of air is required for each pound of water, 8.33 lb., or 1 gal., of water will require 22,532 cu.ft. of air a minute. From this figure a type of fan that will deliver this volume of air against the usual static pressure of the dehydrator, which is 1 to 2 in. of water, can be quickly selected.

Most dehydrators operate on a countercurrent principle in which the trays of cold fruits enter at or near the low-temperature end and are advanced to the high-temperature end, where they are removed. The so-called combination system, in which the maximum temperature is at the middle of the dehydrator, is occasionally used with good results. With this system the fruit enters at one end at the lowest temperature, passes through the high temperature in the middle, and finishes at the other end at a medium temperature.

The sugar in the fruit, particularly

Fig. 2—Dehydrating grapes. Dipping and washing equipment in the left background. A truck of dehydrated grapes is being removed from the drying unit. The open shed construction is characteristic of such establishments in the hot California valleys

Photo from Consolidated Packing Co.

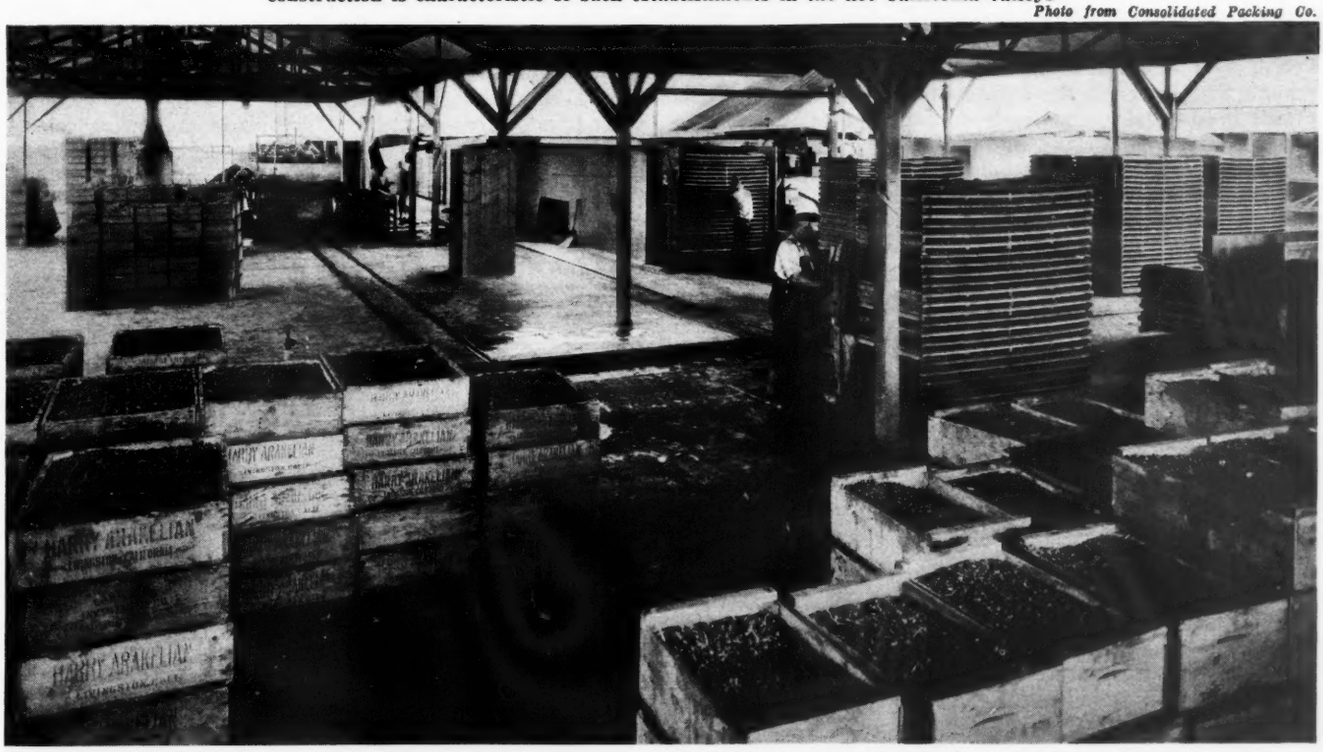


Table I—Comparison of the Drying of Apples, Grapes, and Prunes

	Apples	Grapes	Prunes
Capacity per 24 hours, fresh tons	10*	10	10
Capacity per 24 hours, dry tons	1.5	2.5	4
Shrinkage in dryer	5:1	4:1	2.5:1
Load per square foot, pounds	3	3.5	3.5
Drying time, hours	24	24	24
Spreading area in dryer, square feet	2,500	5,714	5,714
Water evaporated per hour, lb	500	625	500
Over-all thermal efficiency of plant, per cent	40	45	45
Gallons fuel oil required per hour	9.7	10.8	8.6
Air volume required, cubic feet per minute	29,600	28,392	22,532
Air velocity between trays, feet per minute	730	990	750
Maximum temp. hot end, deg. F.	160	165	165
Maximum humidity, hot end, per cent	20	25	25
Maximum humidity, cool end, per cent	65	65	65

Data for apples and prunes from Bull. 485, Calif. Agr. Expt. Sta. (1930).
Data for grapes from Bull. 500, Calif. Agr. Expt. Sta. (1930).

*Apples have to be cored and peeled, so that actual weight of apple slices loaded onto trays is about 7.5 tons.

Table II—Average Costs of Dehydrating Fruits Per Fresh Ton

	Average Requirements* per Fresh Ton			Cost, Dehydrated			Sun Dried
	Apples	Grapes	Prunes	Apples	Grapes	Prunes	Prunes
Labor, man-hours	17.3	6.81	6.08	$6.54	$3.11	$2.60	$3.89
Fuel, gallons	18.5	23.6	20.2	.79	1.10	1.06	.16
Power, kilowatt-hours	41.3	27.2	32.0	.99	.56	.70	.05
Sulphur, pounds	2.8	3.6	(†)	.09	.15	....	....
Lye, pounds	(‡)	2.4	1.8	....	.14	.13	.11
Total				$8.41	$5.06	$4.49	$4.21

* These figures do not apply to sun-dried products. † Sulphur not used in dehydrating prunes.
‡ Lye not used in dehydrating apples. Data from Bulletins 404, 485, 500; Calif. Agr. Expt. Sta.

levulose, begins to caramelize at about 160 deg. F. While it is true that fruit that is losing moisture rapidly probably will not be heated much hotter than the wet-bulb temperature of the air surrounding it, the temperature of the fruit increases as the drying progresses and consequently too high a temperature cannot be used. Finishing temperatures of 165 deg. have been adopted as standard in most fruit-drying operations.

In dehydration practice the effect of humidity on the drying rate and the condition of the fruit is highly important. It is hardly to be expected that the rate of evaporation from material of the cellular structure and syrupy state of fruit tissues should be equal to the rate of evaporation from a free surface. Consequently, when the rate of evaporation from the surface of the fruit exceeds the rate of diffusion of moisture through the tissues to the surface, the surface becomes dry and hard—"case-hardened"—and the drying rate is considerably slowed up. The maximum rate of drying occurs when the fruit is exposed to the highest temperature that will not injure it and to a humidity sufficiently low to minimize retardation in drying and sufficiently high to prevent "case-hardening." The humidity of the air is easily controlled in dryers using recirculation by opening or closing the recirculation dampers and thus decreasing or increasing the quantity of recirculated moist air. The humidity at the outlet of the dryer should not greatly exceed 65 per cent, and at the inlet end, at 165 deg. F., should not exceed 25 per cent. Recirculation has another advantage, since the air at the outlet end of the dryer has by no means exhausted its moisture-carrying power and is ready to take on an additional load if reheated to the temperature of the inlet end. Exhaust air at 130 deg. F. and 65 per cent relative humidity has a relative humidity of only about 30 per cent when heated back again to 165 deg.

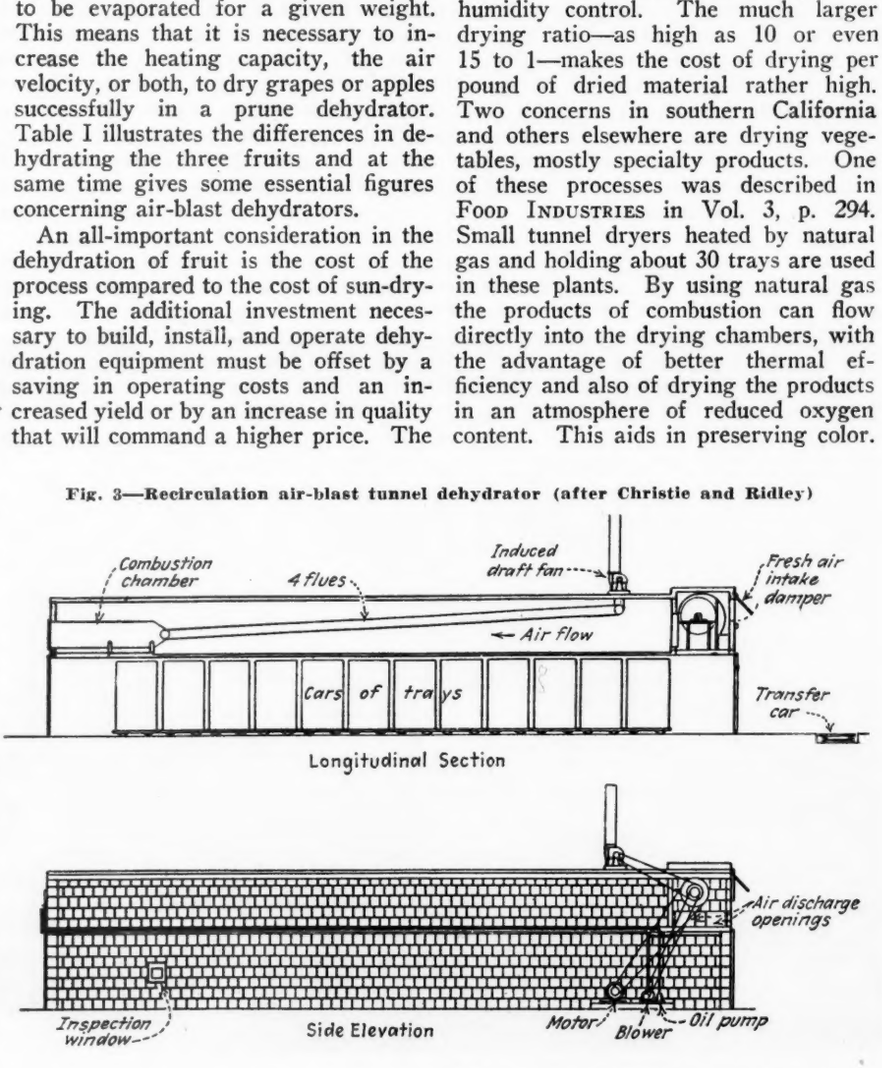
Much the same considerations apply to the dehydration of grapes or apples as have been developed for prunes, except for the fact that more moisture has to be evaporated for a given weight. This means that it is necessary to increase the heating capacity, the air velocity, or both, to dry grapes or apples successfully in a prune dehydrator. Table I illustrates the differences in dehydrating the three fruits and at the same time gives some essential figures concerning air-blast dehydrators.

An all-important consideration in the dehydration of fruit is the cost of the process compared to the cost of sun-drying. The additional investment necessary to build, install, and operate dehydration equipment must be offset by a saving in operating costs and an increased yield or by an increase in quality that will command a higher price. The initial investment per fresh ton drying capacity per 24 hours ranges from $350 to $500, generally decreasing up to a capacity of about 20 fresh tons per day, according to Nichols and Christie. Observations on 25 air-blast dehydrators, operating from 1920 to 1928, and on eleven sun-drying yards give the comparative costs of sun-drying and dehydrating prunes shown in Table II. This table also shows costs and cost item requirements for apples and grapes.

The cost of drying Thompson grapes, shown in Table II, must be multiplied by four to get costs per dry ton. In Oregon, Wiegand has estimated the total cost of drying prunes in a recirculation tunnel dryer at 1.2c. per pound (Station Circular No. 40, Oregon Agricultural College Experiment Station). Christie and Nichols (Bulletin No. 404) estimate $8.12 per fresh ton by dehydration, including all charges, as against $7.64 for sun-drying.

Dehydrated vegetables have never attained the widespread use that the dried fruits have, partly on account of their high price and partly because of the additional time required for preparing them for use. As far as the drying of them is concerned, it can be carried out by much the same equipment as is used in the dehydration of fruits, with perhaps a little more attention paid to humidity control. The much larger drying ratio—as high as 10 or even 15 to 1—makes the cost of drying per pound of dried material rather high. Two concerns in southern California and others elsewhere are drying vegetables, mostly specialty products. One of these processes was described in FOOD INDUSTRIES in Vol. 3, p. 294. Small tunnel dryers heated by natural gas and holding about 30 trays are used in these plants. By using natural gas the products of combustion can flow directly into the drying chambers, with the advantage of better thermal efficiency and also of drying the products in an atmosphere of reduced oxygen content. This aids in preserving color.

Fig. 3—Recirculation air-blast tunnel dehydrator (after Christie and Ridley)



Drying Gelatine on a Wheel

By L. M. TOLMAN
Vice-President,
United Chemical & Organic Products Co.
Chicago, Ill.

Fig. 1—Gelatine drying wheel, with liquor pan in foreground at center, and knives for removing gelatine below

GELATINE drying has been the subject of much study. The patents over a period of many years have disclosed numerous devices and methods, but practically all of the gelatine plants are using today the tunnel method of drying which has been in use for many years. In order to make a comparison between this method of drying and the wheel method of drying, a brief description of the standard method is given.

In the tunnel method, long drying tunnels or alleys are so constructed as to receive trucks stacked with 20 or 30 frames covered with aluminum screen, on which is laid a thin layer of gelatine jelly. Heated air is blown countercurrent to the direction that the trucks are pushed into the tunnels. The quantity of air used is enormous. In some plants it runs as high as 400,000 cu.ft. per minute. From 8 to 12 hours is required to dry the gelatine.

It can readily be seen that the moist jelly on these frames will pick up dust and dirt from the air with great facility, so the building of elaborate air filtration systems is necessary. These air filtration systems are not only expensive to install but also to operate, as they continually build up an increasing resistance to the air as they collect the dirt and dust from the air, thus bringing about added power consumption.

There is, in addition, a further limitation to the air drying system, because at times, especially during the summer, the outside air is so high in temperature and humidity that it becomes very difficult to dry gelatine. An elaborate system for air-conditioning would overcome this difficulty, but up to the present time has not been used because of the great expense involved both in the matter of installation and operation.

With these difficulties in mind, it has been the idea of manufacturers of gelatine, for many years, to devise a drying process in which some of the objections to the air-drying methods could be corrected. The objects toward which we were striving in developing the wheel system of drying, were: To shorten the time of drying; to do away with the necessity of air filtration; and to provide an equipment which could dry gelatine the year around without air-conditioning equipment.

In 1914 and 1915 experimental work was begun in the plant of the United Chemical & Organic Products Co. with the idea of developing a method of drying which would do away with these difficulties. Dr. A. Sweitzer, at that time technical director of the company, began a long series of experiments, both on a laboratory and a semi-manufacturing scale, until he finally developed what is now known as the drying wheel, used by the company in making "wheel-dried" gelatine. The first commercial installation was a comparatively small wheel, 12 ft. in diameter and 3 ft. across. This wheel worked with so much satisfaction that four additional wheels were built. These additional wheels are the ones now in operation, and Figs. 1, 2, and 3 show in a general way the character of the design. The wheel is mounted on a 12-in. shaft, hollow at each end for steam inlet and for a condensate drain. The wheel proper is 18 ft. in diameter and 3 ft. wide. The drying surface is made up of hollow steam pads about 6 in. thick, bolted together. The outside diameter of the wheel is 20 ft., the face 49 in. Each of the pads has a steam inlet and a condensate drain. The wheel is made up of 12 of these steam pads. Steam enters through one end of the hollow shaft into a header and is piped to each pad. The condensate line from each pad is connected to a header at the other end of the hollow shaft and passes through a steam trap. About 20 lb. steam pressure is maintained on the pads.

Across the face of the wheel is the liquor pan (see Fig. 1) which fits tightly to the surface of the wheel. This pan is supplied with gelatine solution from the storage tank. The finished, dried gelatine is taken off by a series of staggered knives adjusted with tension springs in such a manner as to cut, rather than scrape, the gelatine from the surface of the wheel. The whole system is covered with a vapor duct built around the drying surface and connected with a fan which draws the vapors away (shown in Fig. 2).

The wheel makes a revolution

ordinarily in from 45 to 60 seconds. During this time the gelatine is completely dried and cut off from the surface in continuous ribbons about 5 in. wide. The dry gelatine drops into a conveyor and is carried to a mill where it is ground to No. 8 mesh and delivered directly to the barrels in which the product is finally shipped. Each wheel has a capacity of from 75 to 80 lb. of finished gelatine per hour. Less than one hour is required for the liquid coming from the cook tanks to run through the filter and dry over the wheels, when it is a finished gelatine ready for shipment.

From this description, it can be seen that in this method of operation we have overcome three of the chief problems in the drying of gelatine. We have reduced the time to a minimum, done away with enormous air filtration systems necessary to provide the volume of air used in the drying tunnels, and have developed a system that can be operated in summer as well as in winter. Surprising as it may seem, the heating of the gelatine on the wheel does not increase its insolubility, nor does it act as a sterilizer to any appreciable extent. It is in the matter of quick handling that the principal benefit is obtained. We find it is just as necessary in this method of operation to have a sanitary system of handling of liquors up to the drying as it is where the tunnel system is employed; therefore extreme precautions in regard to the sanitary handling of the liquors are always taken.

In the cook room and the filter room it is necessary that very great care be taken in handling gelatine liquors in order to prevent the growth of bacteria. In the cook room, where wooden cook tanks are used, a special system of installation was employed so that every tank would absolutely and completely drain. These tanks are subjected to a special treatment after each operation, so that they remain sterile. They are elevated sufficiently so that the liquors, as they are drawn off, can flow directly into glass-lined receiving tanks in the filter room. This filter room is designed with the requirements in view and in its construction every possible precaution has been taken to prevent any bacterial contamination. Sanitary type nickel piping is used in conveying the liquor from the filter presses, to the evaporators and to the drying equipment. Gate valves are used wherever possible, because of the eliminating of pockets. As a matter of fact, in the handling of gelatine it is most important to avoid any pockets where liquor can stand.

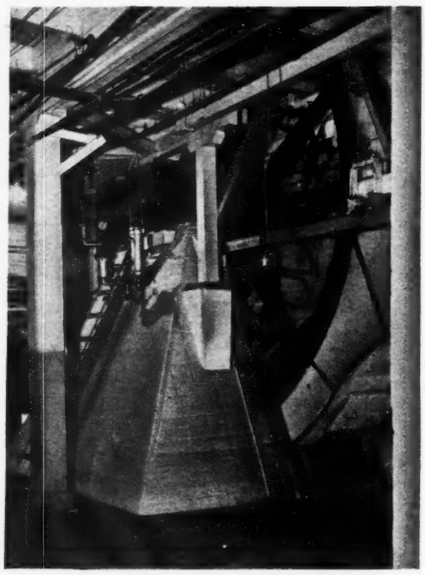
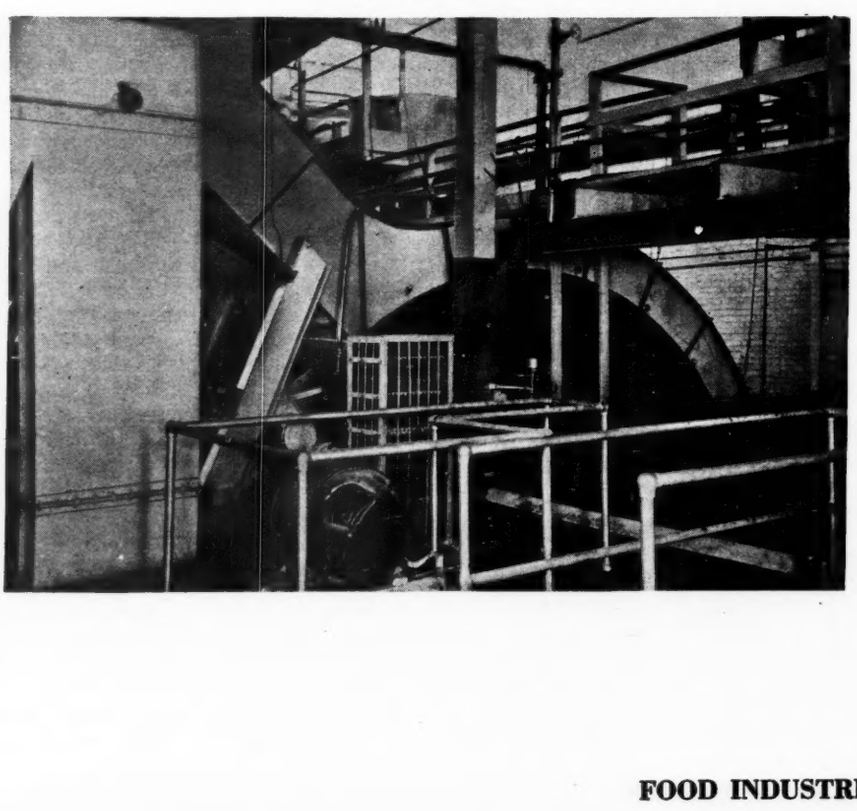


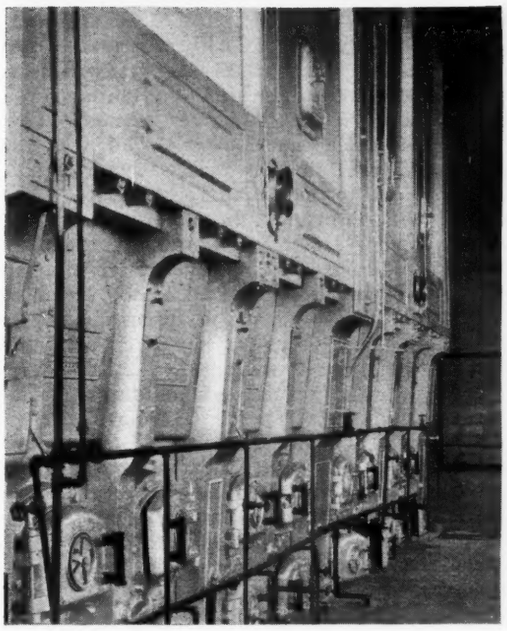
Fig. 3—One of piers on which gelatine drying wheel is mounted, showing steam control

The gelatine produced in this sanitary filter and cook room, and dried on the wheel a few minutes after it leaves the filter, is practically a sterile product. Wheel-dried gelatine has an entirely different appearance from the gelatine dried in the drying tunnel. The flake gelatine from the wheel is more readily soluble than the tunnel-dried, and can be dissolved by agitating with warm water without previous soaking. In the manufacture of ice cream it is possible to dissolve wheel-dried flake gelatine by putting it directly into the pasteurizer in the dry form. It also has certain other physical properties which make it desirable from the standpoint of manufacture of marshmallows and ice cream.

The perfection of this method of drying gelatine and the introduction of its product on to the market was a rather remarkable piece of work. During the period of development of the wheel, experiments were made with spray drying, and as a matter of fact a large commercial spray-drying unit was put in, but with unsatisfactory results. Drying on a continuous heated belt also was tried during the experimental period, but the finally developed wheel undoubtedly is the only successful equipment that has been made to dry gelatine other than by the tunnel method.

Fig. 2—Top of gelatine drying wheel showing duct for removing vapor given off during drying





Battery of Sterling water-tube boilers in a large Western canning plant. Firing by gas makes it easy to maintain an immaculate boiler room

The canning industry *is* heat application. A well-managed plant means well-managed heat, from wash water to exhaust box. In this article, Robert Dillman, manager of one of the largest canning plants in the country, at Blue Island, Ill., a mechanical engineer by training and a member of the A.S.M.E., begins a description, based on 20 years' experience, of efficient production and use of heat in canning. The second half of Mr. Dillman's article, covering open cookers, retorts, exhaust boxes and evaporation equipment, will appear in an early issue.

How the Canning Industry Uses Heat

THE fundamental principle of canning is the sealing of food products in airtight containers followed by killing of bacteria and enzymes by means of heat, which is the most economical and the only practical method. Any other means of attaining this end would involve the use of chemical preservatives, which are objectionable in food products. Even with some items which are preserved by freezing it is necessary first to kill the enzymes by heat to have a satisfactory finished product. Heat has many other uses in canning, such as peeling, scalding, soaking, evaporation, baking, cooking, and exhausting.

Heat is a form of energy. As such it must always be associated with some substance as a means of conveyance. Canneries purchase potential heat, as a rule, in the form of coal, gas, or oil, and make it available for use by burning, which produces hot gases. In some instances these are used directly, but usually the heat is transferred to water in a boiler which, in turn, transfers the heat to points where it is needed, either as hot water or steam. Heat can be measured and the unit of quantity is the "British thermal unit," or B.t.u., which is the quantity of heat necessary to raise 1 lb. of water 1 deg. from 62 deg. to 63 deg. F.

In this article we will not discuss the boiler plant, for there is already available a world of technical and semi-technical literature covering the subject, but we will start in most instances with steam and in some cases try to arrive at a thermal efficiency of pieces of apparatus in which it is used.

This is a new field and very little definite information of any kind is available. Machinery manufacturers and experienced cannery men know about how much rated boiler capacity to allow for various operations, but on the whole these are only guesses. This article will deal with general canning only, and will not include evaporated milk canneries, which is rather a specialty in itself.

Direct Flame and Hot Gases

The use of flame or hot gases gives the greatest temperature range possible to attain. It can be anywhere from room temperature to more than 2,000 deg. F. It is very difficult to regulate, carries a comparatively small quantity of heat in the lower temperature range (500 deg. F. and less), and consequently is not used in ordinary canning operations. Its two main uses are scorching pimento peppers to remove the skins and heating the ovens for genuine oven-baked pork and beans.

In peeling pimento peppers, they are subjected to the direct action of a gas flame. Although the temperature probably is between 1,200 and 1,500 deg. F., only the outer layer is very quickly heated and scorched. Moisture under the skin is turned to steam, which loosens up the pieces of skin so that they can be washed off with water. I do not know of any scientific data on the subject.

In the baking of pork and beans, an open flame is used in the ovens. A temperature between 400 and 500 deg. F. is used and a regular bake is given. The ovens can be fairly well controlled and are similar to ordinary bakery ovens.

Use of Steam

The use of steam for distributing heat throughout a canning plant is so universal that it is really the backbone of the whole procedure. In most plants, steam alone is used, and when hot water is needed it is provided at the point of use by heating cold water with steam. The study of heat in a cannery therefore is principally a study of the use of steam and is based on very good reasons, the main one of which is that it is the only carrier of

heat which changes its physical state within the proper temperature range and gives up its latent heat of evaporation. This one fact means that steam can transfer heat to other objects and raise their temperatures or boil water without decreasing its own temperature. This property permits easy control in retorts and pressure cookers, and provides an automatic temperature control of an open-water bath without any regulatory apparatus. The temperature of boiling water varies a little with the altitude, of course, but even so it is very satisfactory for a great many uses.

Another fortunate characteristic of steam is that 1 lb. of steam at atmospheric pressure amounts to 26 cu.ft. at 212 deg. F., but after giving up 970 B.t.u. of heat it remains at 212 deg. temperature but measures only about 1/62 cu.ft. and is, of course, water. If it were not for this fact our present retorts, exhaust boxes, cooking coils, and many other simple items of cannery equipment would be much more complicated and expensive, and more difficult to control than they are now. Also, if it were not for this fact, vacuum evaporators would be practically impossible.

A further advantageous property of steam is that the temperature of saturated steam varies according to its pressure. Its practical range of variation is almost ideal for the canning industry, which employs temperatures obtained in this way from about 140 deg. F. to 250 deg. F. for canning and preparation, and as high as 350 deg. F. in pipes and coils for transportation of heat and for boiling operations.

Steam is used in a cannery to supply heat either by a direct or indirect method, or by a combination of the two. As a rule, the direct method is the most efficient, but our primary concern is not so much for efficiency as it is for suitability for the purpose. In general, when steam is used directly in the product, a steam separator should be placed in the line close to the point of use and it should be drained by a steam trap. Proper steam separation will eliminate to a great extent the objectionable flavors which sometimes are found in products where steam is used directly. Such a precaution is especially important in small plants with boilers working under heavy loads, where priming is almost certain to take place.

The majority of uses for steam in a cannery involve indirect heating where no such troubles occur. Some pieces of apparatus, like the exhaust box, use steam both directly and indirectly, although indirect use of steam for heating is the one most often employed here.

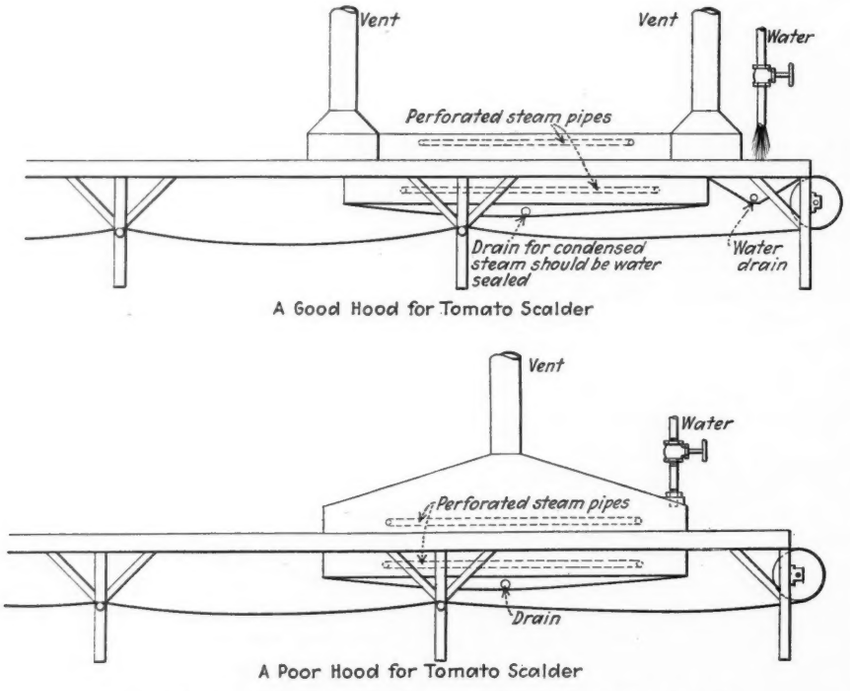


Fig. 1—For a good tomato-scalder hood, the water spray should be outside to avoid condensation of steam

Scalding Tomatoes

In following products through their respective canning processes, the first large use of steam is found in connection with peeling. The first operation of this kind is the scalding or steaming of tomatoes to loosen the skins so that they may be removed easily. The steaming takes less than a minute and only the outside layer of the tomato is affected. The centers of the tomatoes are not appreciably raised in temperature.

If we consider a single line of machinery running on No. 2½ size cans and figure on 220 lb. of tomatoes per minute with an average rise in temperature of 10 deg. F., the tomatoes absorb 2,200 B.t.u. per minute. Now a boiler horsepower is defined as 33,479 B.t.u. per hour, which is equivalent to 558 B.t.u. per minute. The heat absorption, therefore, is at the rate of 3.94 boiler horsepower. To calculate this back to the boiler and arrive at an equivalent boiler load is too technical for the scope of this discussion. It is sufficient to say, however, that this would be equivalent to 4.2 hp. under the usual operating conditions found in canneries.

If we knew the actual horsepower delivered to the scalder, we could arrive at its thermal efficiency, but here we are lost. Some tomato canneries will use 10 hp. and the efficiency will be 42 per cent, while others will use 20 hp. and the efficiency will be 21 per cent.

The reason for this great variation is found partly in carelessness of operation and partly in design of the scalder. Most scalders in use today are perforated, woven, or slat metal conveyors passing through steam chambers. Since the object of the scalder is to subject every portion of the tomato to hot steam as quickly as possible, slat conveyors obviously are very poor. The construction of the hood also is important. Fig. 1 shows both a poor hood and a good one. If water is used to spray the tomatoes after scalding, the spray should be placed outside and away from the hood, for if it comes in contact with the steam it may greatly increase the steam consumption by condensing much of it.

A recent attempt has been made to go a step beyond the scalder for tomatoes and literally blow their skins off. The idea is based on the fact that there is a definite boiling point for water, depending on the pressure to which it is subjected. Tomatoes are put into a steam box capable of withstanding 15 lb. external pressure. The door is closed and steam is now admitted until all the air is forced out. The surfaces of the tomatoes are heated by this steam for an instant and then the valve is closed, and likewise the vent. Cold water is next quickly injected into the chamber, and condenses the steam. A vacuum is thus caused to form and, because the moisture under the skin is above the boiling point, it explodes and blows the skin off by its own steam pressure. Steam consumption of this system should not be as great as that of a scalder, but its industrial success will depend on the auxiliary mechanical equipment that has been developed to make it practical. It affords, however, an example of applying heat by steam, with its characteristic properties, to the solution of the canners' problems.

Lye solutions heated by steam for peeling peaches and certain vegetables are an example of direct heating with

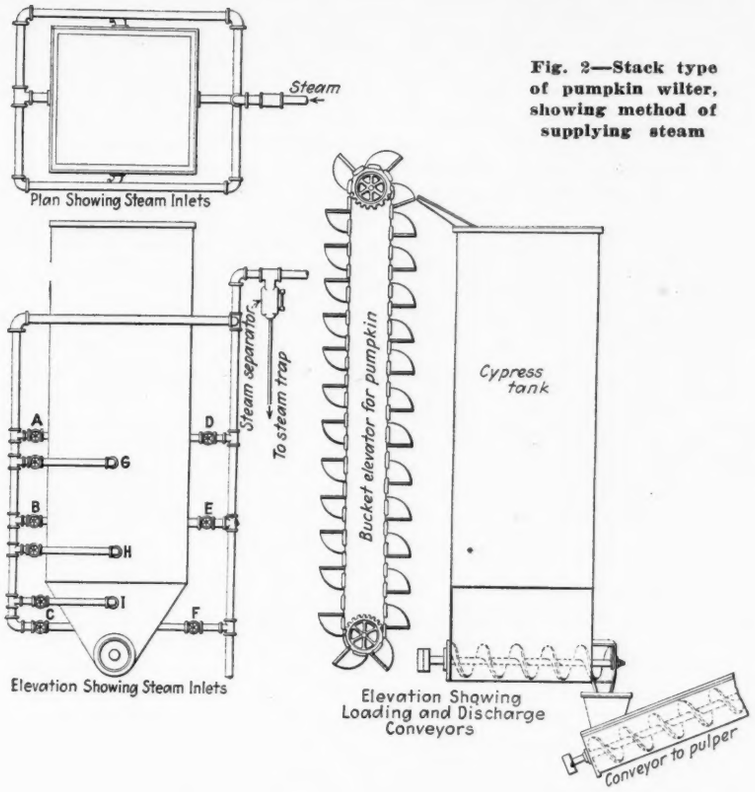


Fig. 2—Stack type of pumpkin wilter, showing method of supplying steam

live steam, but also involve indirect heating of products by the lye solutions. The heat transfer is similar to that of the scalder to the end that the quantity of steam required depends on the quantity of peaches or vegetables passing through. The lye solution can be sprayed on the produce or the produce can be dipped into it. The thermal efficiency of the lye peeler is greater than that of the scalder, and the dip type of equipment is more efficient in steam consumption than the spray type.

Blanching

Blanching, or wilting, is an operation involving a very extensive use of steam for preparing products for canning. If the product is not subsequently permitted to cool down again, this initial heat is a part of the chain of temperature increases which eventually result in raising these products above the thermal death point of the bacteria which would otherwise cause their spoilage. Pumpkin and squash retain much of this initial heat, but most other products become fairly well cooled and so must be heated again.

Let us consider, first, the blanching of pumpkin. The object of heating is to break down the entire structure of the product and liberate some of the large quantity of water which it contains. For this reason the steam consumption is high. Let us assume that we are running 10 tons of seeded and trimmed pumpkin, or 20,000 lb., per hour. Usually it is cool at the start and will have to be heated up from 50 deg. F. to 212 deg. F., an increase of 162 deg. F. The heat necessary, considering pumpkin to have the same specific heat as water, will be 20,000 x 162, which equals 3,240,000 B.t.u. per hour. Dividing this by 33,479 gives us about 97 hp. of boiler capacity in the form of heat actually transferred to the pumpkin. This will require about 104 hp. at the boilers, according to the manner in which the usual cannery boiler is operated, if the thermal efficiency is considered to be 100 per cent. No actual figures are available, but it is probable that only about 80 per cent is realized, after allowing for radiation and steam losses at the wilter, so that about 130 hp. would be the boiler capacity required in this operation.

The usual wilter is a device which heats by the direct application of steam, which means that the condensed steam, amount to about 3,300 lb., is added to the pumpkin, or about 16½ per cent of the weight of pumpkin fed into it. This refers to the stack-type of wilter, and is the reason why there is such a large quantity of water to drain or press out of the pumpkin which has been steamed in this way.

Beets are steamed in a manner similar to pumpkin except that the steamer is horizontal and the condensed steam drains away. The steam consumption would be figured in a similar manner, however, based on the weight of beets fed and the temperature rise.

Hot Water Blanch

The hot water blanch, as used for peas and string beans, is different from the steam blanch. The water is heated directly by the steam, but the product itself is heated indirectly by the water. Let us consider a blancher on green beans for a canning line running 60 cans per minute. This would require about 50 lb. of prepared beans per minute. The blanch at 180 deg. F., together with an initial temperature of the beans at about 75 deg. F., requires a temperature rise of 105 deg. F., indicating a heat consumption of 5,250 B.t.u. per minute, or 315,000 B.t.u. per hour, or about 9 hp.

The purpose of this blancher is twofold, however, and washing in hot water is the second purpose. To wash properly, fresh water must be constantly added, usually in a funnel at one end. The quantity of water so added to the blancher varies greatly, but a reasonable quantity is one-half the weight of beans fed. The temperature of this water also is usually low and so requires more heat. If it is at 65 deg. F., as fed, the temperature rise is 115 deg. The heat necessary is then 25 x 115, or 2,875 B.t.u. per minute, or 172,500 B.t.u. per hour, or about 5.2 hp. additional. This makes a total absorbed boiler horsepower of 14.2 at the blancher. No figures are available on the efficiency of blanchers, but 80 per cent probably is a fair estimate, so that 17.75 hp. is needed at the blancher, equivalent to about 19 hp. at the boiler. This is a fair figure for blanching at 180 deg. F., but it is below the boiling point and automatic temperature controllers probably will be used.

If, however, a boiling water blanch is used, controllers are not possible and, if installed, they do not control. In this case the blancher may become a great waster of steam and actually use 100 hp. or more.

This brings us to a discussion of automatic temperature controllers. They are very efficient, especially the air-operated instruments, which control to

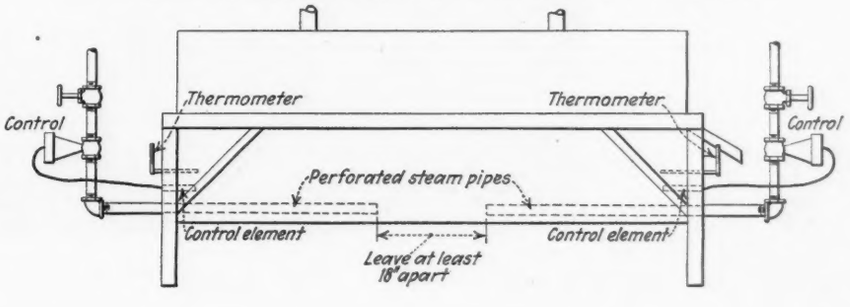


Fig. 3—An efficient blancher has temperature regulators at each end, and steam pipes are separated at the center to avoid overlap

a very fine degree. It must be remembered, however, that they are actuated from the spot where the bulb or control element is located *and at that point only*. A check thermometer should be located near this point to see that the controller is operating properly, but a thermometer placed farther away may indicate temperatures either higher or lower and give the erroneous impression that the controller is not working. Most blanchers, therefore, should have a controller and thermometer at each end. This, however, is not all. Controllers operate steam valves which allow steam to enter the blancher through the perforated distributing pipes, which must be separate and not overlap (see Fig. 3). A blancher with a large water tank and a good means of circulation may do good work when operated with a single controller, but on delicate products, like green beans, a controller at each end is much better.

Just consider what happens in the ordinary blancher with a single controller on the inlet end but with steam inlets at each end and perforated pipes for heating, overlapping throughout the entire length. This description represents many blanchers as supplied by manufacturers and actually in use. The controller operates the steam supply for both ends. Suppose the blancher is running idle and is exactly at 180 deg. F. throughout. Cold beans are fed into the inlet and cool down this water. The controller then opens the steam valve and allows steam to enter the blancher from one end to the other. The water in the middle and discharge end probably will boil as a result, although the controller and thermometer still indicate a temperature of 180 deg. Thus your beans will get a variable blanch all the way up from 180 deg. F. to the boiling point. For a quality pack of small green beans, this makes a difference, although it may make little difference on some other products. At any rate, if a controlled blanch is wanted, it should be controlled as completely as possible, and a blancher connected as shown in Fig. 3 will accomplish this purpose.

All controllers operate on a differential of temperature. When the temperature actually drops it contracts the control element and opens the steam valve, and when it rises again it shuts off the steam. This differential may be a fraction of a degree in the case of air-operated instruments, but probably will be several degrees on self-contained controllers. If, therefore, a controller is set at the boiling point it will not function, for the temperature of the water cannot go above the boiling point to shut it off. For blanchers, however, where temperature alone is required, but not actual boiling, the controller may be set just enough below the boiling point to operate properly. For air-operated controllers this may be about 2 deg., but for self-operated instruments it will require much more. This makes an efficient control and the small temperature differences, especially with air-operated instruments, may be neglected.

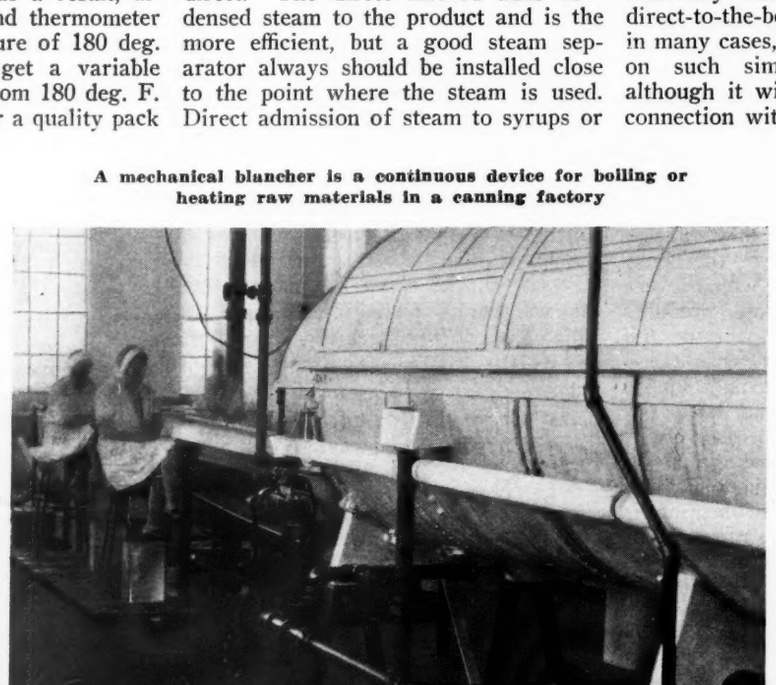
Heating Brines and Syrups

Another use of steam in the preparation of products prior to canning is for heating water, brine, and syrup to be added to the cans and also for heating of corn for cream-style pack. This operation may be either direct or indirect. The direct method adds condensed steam to the product and is the more efficient, but a good steam separator always should be installed close to the point where the steam is used. Direct admission of steam to syrups or brines is not satisfactory, on account of the diluting effect of the condensate, and the indirect method must be used.

For purposes of figuring the steam requirements, the material may be considered to have the same specific heat as water. The unit quantity of 1,000 lb. of material is used for computation. It is not strictly accurate for all products, for the specific heat or the B.t.u. necessary to raise 1 lb. 1 deg. F. will be different for different products, but in no case will it be more than water. As water weighs 8⅓ lb. per gallon, our unit batch is equivalent to 120 gal. The element of time enters the computation when figuring horsepower, so we will assume that our batch is heated in 5 minutes to the boiling point from 70 deg. F. The temperature increase is 142 deg., which multiplied by the weight gives 142,000 B.t.u. per batch, used in 5 minutes, or an average rate of 1,704,000 B.t.u. per hour. This quantity of heat is equivalent to 51 boiler horsepower at the heating tank, and is equivalent to almost 55 hp. at the boilers. It is probable that 90 per cent efficiency will be realized, so that the actual boiler output necessary will be 61 hp. If any large quantity of water or similar substance is to be heated quickly, a large boiler capacity is necessary.

If the batch is heated by a steam coil of sufficient size to bring the liquid to boiling in 5 minutes, and is trapped with the ordinary steam trap, the discharge of which returns to the boiler room to be used in an open-feed water heater, the boiler horsepower necessary will be almost the same. A direct-to-the-boiler system saves heat in many cases, but it is not worth while on such simple heating operations, although it will be a big advantage in connection with evaporating equipment.

A mechanical blancher is a continuous device for boiling or heating raw materials in a canning factory



By E. S. PATTISON
Assistant Editor, Food Industries

A typical Vermont maple sugar camp

The Wood Fire Still Serves In Making Maple Syrup

BECAUSE pure maple sugar is not pure sugar, its value is more than ten times as great. In the sap of the sugar maple, as it begins its spring-time flow, is dissolved about 2 per cent of sucrose. But it is the remaining few thousandths of a per cent of dissolved solids that puts maple sap on an entirely different economic plane from other sources of sucrose.

Analysis of the sap reveals, in addition to sucrose, traces of reducing sugars, organic acids (chiefly malic), mineral matter (chiefly calcium and potassium salts), and albuminous material. Geographical and seasonal variations in composition are very great. To produce 1 gal. of maple syrup of standard density of 11 lb. per gallon (35.6 deg. Be. at 60 deg. F.), the sap evaporated may vary from 25 to 50 gal.

The economic value of maple products depends almost exclusively upon flavor and color. The sucrose solution is, in reality, merely an inseparable vehicle for this flavor. Concentration of the sap by means of heat, therefore, is primarily a problem in flavor and color preservation. Efficiency of evaporation on the basis of fuel cost per pound of water evaporated is of far less relative importance. The price differential between No. 1 grade syrup and the next lower grade, for example, is normally greater than the entire fuel cost (estimated* at $0.27 per gallon of syrup).

Rapidity of evaporation has been found to be the key to quality syrup, although it is limited, of course, by the alternate danger of scorching. The basis of the grading system used is color—the lighter the color of the syrup of standard density, the higher its market value. Darkening of the syrup, with an accompanying change in the delicate flavor, is directly related to changes in the albuminous constituents with prolonged high temperatures.

It becomes perfectly obvious, then, why "shallow boiling" in pans of large surface area has supplanted kettle boiling in all but the most primitive of sugar camps. Liquid level in the modern evaporator is maintained constant (at $\frac{3}{4}$ to 1 in. in the small pans) by a float valve. Baffles and corrugations in the pans lead to rapid circulation. Every effort consistent with other economic factors has been made to enlarge the area of heating surface by corrugations and deep flues.

Direct fire from wood, the naturally available fuel, obviously is the logical method of obtaining the high rate of heat supply necessary. In addition to radiation and convection to pans immediately above the fire, the design of the "flue-type" pan assures increased efficiency from the hot gases at the chimney end of the arch.

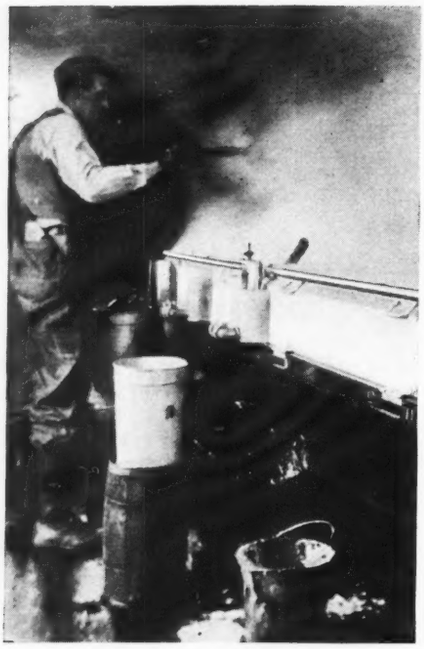
Because the equipment used in maple-syrup boiling is simple and low in initial cost, in comparison with evaporating equipment in other types of food production, it usually has been described in "back-to-nature" fashion, with the general implication that the process is delightfully, albeit inefficiently, primitive. For a large number of sugar camps, any implication of inefficiency is unjustified, so far as the evaporating equipment is concerned, when all the circumstances are considered.

The period of production, for instance, is limited by the sap flow to from three to six weeks, and is not continuous within this period. It has been estimated* that a camp producing 125 gal. of syrup per season will have the lowest boiling cost with an evaporator producing 2.5 gal. of syrup per hour (about 75 gal. of sap). In other words, the actual evaporating time would be as low as 50 hours per season if operated at full capacity. Almost 50 per cent of the variation in cost of production is caused by differences in the yield of sap from year to year.* Differences in the sugar content of the sap, though it may increase the quantity of water to be evaporated per gallon of sap by 100 per cent, have been estimated to cause a difference in the cost of production of only 2.7 per cent.

These factors make flexible equipment of low initial cost considerably more important than absolute heat efficiency. The saving of a cord of wood per season, which would look quite enormous expressed as B.t.u. per hour of evaporating time, ordinarily would be wasteful if interest charges on an additional $100 of capital expense had to be borne. Evaporation with steam would permit closed temperature control, but interest charges on such equipment eliminate it as an economic possibility in the usual sugar camp. As a matter of fact, a U. S. Tariff Commission investigation in 1928 placed the average value of maple sugar equipment in Vermont per producer, including buckets, spouts, collecting kettles, and the like, as well as the evaporator, at $736.

There are binding economic reasons, as well, why syrup boiling must be conducted in relatively small units as near as possible to the source of sap. Transportation of a liquid containing over 95 per cent water any considerable distance through spring snow or mud would be an expensive procedure at best. Moreover, the sap is susceptible to fermentation. Buckets must be emptied at least once a day. Delay for more than a few hours after the sap is collected, on warm days, makes

*J. A. Hitchcock, Bulletin 292, Vermont Agricultural Experiment Station, Burlington, Vt.



About 35 gal. of sap must be evaporated to produce a gallon of maple syrup

it impossible to produce a high grade of syrup or sugar. Evaporators of one manufacturer range in capacity from 100 to 3,500 buckets of sap in continuous hours of daylight boiling, or about nine hours—corresponding to a capacity of from 15 to 350 gal. of sap per hour. In Vermont, an evaporator with a capacity of about 125 gal. of sap per hour is about average size.

The evaporator itself is essentially an iron firebox and arch lined with firebrick, and supporting evaporating pans of tin plate. The length of the evaporator from firedoor to chimney usually is about three times the width. The firebox must be large enough to take 4-ft. wood. A well-constructed arch will allow the blaze to rise vertically, strike the evaporator close to the front end, and hug the bottom of the pan slightly beyond the arch. To insure this, the throat of the arch must be shallow and fitted with dampers.†

Number, arrangement, and design of the pans vary with capacity, price, and the particular operating conditions. G. H. Grimm Co., Rutland, Vt., a leading manufacturer of this equipment, constructs pans of "Cookley K," No. 22 gage, tin plate imported from England. Galvanized iron has been found unsatisfactory. In general, 1 sq.ft. of corrugated bottom is capable of concentrating 2 gal. of sap per hour.†

In the "Champion" type of evaporator, which has been popular for many years, the sap enters the pans at the firebox end of the evaporator. The 4x12-ft. evaporator, which will handle from 100 to 115 gal. of sap per hour, has one 4x8-ft. pan and two 2x4-ft. syrup pans. The sap flows by gravity from the storage tank outside the building through the regulator into the corner of the corrugated pan from the front to the back end, 8 ft.; then through the partition into the center section, forward 8 ft.; then through a partition into the side section to the first siphon, which carries it to the first syrup pan. The total flow, including the several sections of the syrup pans, is 56 ft., and corrugations make this equivalent to an 80-ft. flow over a flat surface. When syrup is to be drawn from the final pan, flow into this pan is shut off for a short interval.

Deposition of "sugar sand," a hard deposit composed chiefly of calcium malate, in the final syrup pan is a serious problem in some localities, as it increases the danger of scorching the syrup. It is ordinarily removed between runs by lactic acid in the form of sour milk, although dilute hydrochloric acid may sometimes be necessary. A "reversible flue type" evaporator, which has one syrup pan divided in two separate sections, sometimes is used when "sugar sand" deposition is particularly high. In this arrangement, one side of the syrup pan is used as an intermediate between two large pans. When deposition becomes noticeable, the flow is reversed, so that less concentrated sap flows through the section formerly containing the final syrup, and syrup is drawn off from the opposite side of the evaporator.

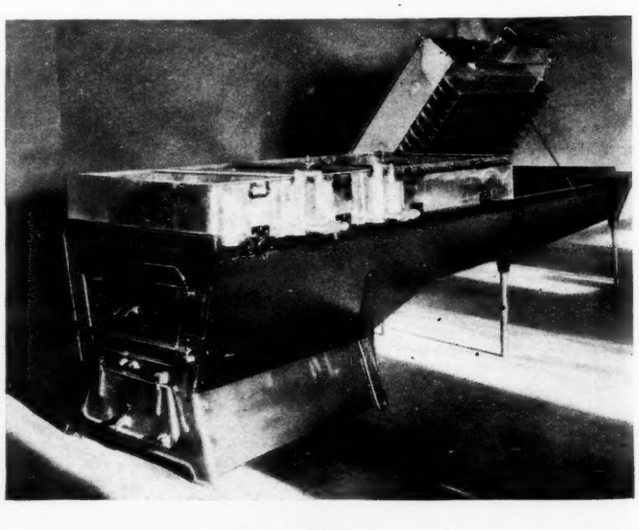
The "regular flue" type of evaporator probably is the most efficient for general use. Four pans are used, that into which the sap initially flows containing hollow longitudinal flues or grooves which project about 5 in. down into the path of hot gases and increase the surface area materially. This pan is located at the chimney end of the arch, and the increased surface area raises the capacity of this type of evaporator about 30 per cent. The second pan is of the usual corrugated, "shallow-boiling" type, and the two syrup pans, though several inches higher, are similar to those used in the ordinary evaporator, but located at the opposite end of the arch.

Operation of the evaporator, for one who can build and maintain a good wood fire, is relatively simple. A scum of coagulating albuminous material must be removed from the surface of the liquid at frequent intervals, and temperature in the syrup pan must be watched continuously. A boiling temperature of 219 deg. F. (at sea level) is equivalent to syrup of standard density, containing about 65 per cent of sugar. Foaming of the liquid in the pans is checked by sprinkling a few drops of cream on the surface. In the "good old days" of kettle boiling, a piece of salt pork served this purpose, according to tradition.

Cleanliness, of course, is a prerequisite for the production of high-quality syrup. When drawn off the evaporator in the sugar camp, the syrup is commonly filtered through a felt bag, chiefly for the purpose of removing the precipitated calcium malate. Further clarification is necessary after the syrup has cooled, particularly if it is to be sold as high grade syrup in commercial channels.

At the plant of G. H. Grimm Co. about 65,000 to 75,000 gal. of syrup per season is collected from farm sugar camps, much of it "in trade" for maple sugar equipment. This syrup is standardized as to density in a 300-gal. tank heated by steam coils, and then filtered through a plate-type filter press. It is bottled at 185 deg. F., sealed, and then pasteurized in a steam-heated water bath at 190 deg. for about 5 minutes. This syrup is crystal clear and will retain its flavor indefinitely.

Smaller "sugaring off" arches usually are used for sugar camp manufacture of maple sugar. Here, however, the economic advantages of operating "close to nature" are not applicable, and much of the sugar of best quality is made in larger lots from syrup collected from farm evaporators. G. H. Grimm Co. makes more than 500 lb. of sugar per day during the producing season. The syrup is evaporated in steam jacketed kettles, followed by cooling and mechanical agitation in small containers, from which it is poured when the proper degree of crystallization has been reached.



A modern sap evaporator, showing the "flues" in the first pan which increase the area of heating surface

†Bulletin E-167, New York State College of Agriculture, Ithaca, N. Y.

Sugar Liquor Evaporation Ties In With Power Supply

By FREDERICK M. GIBSON
Plant Engineer, American Sugar Refining Co.
Brooklyn, N. Y.

THE use of heat for evaporation in sugar refining presents three major considerations: thermal efficiency of the equipment, balancing of steam systems, quality of product. Of these, the problem of thermal efficiency is the most clear cut, involving primarily the selection of single- or multiple-effect evaporators. The balancing of steam systems concerns the supplying of sufficient use for exhaust steam produced in the generation of power. The quality of product is a question of sufficient and proper distribution of heating surface to obtain rapid and uniform circulation of the sugar solutions.

The raw sugar arrives at the refinery in a crystalline form with about 3 per cent of non-sugars and 4 per cent of syrup. Syrup, it may be explained here, is an invert sugar which cannot be crystallized. The crystals are mixed with syrup from previous refining to provide enough fluidity to permit handling in a centrifugal machine when the crystals are washed. Then, for the purpose of defecation and filtration, they are melted into a liquor with a ratio of about 1 lb. of sugar to ⅔ lb. of water. This means that an average refinery melting 2,500,000 lb. of sugar a day must evaporate approximately 1,667,000 lb. of water per day.

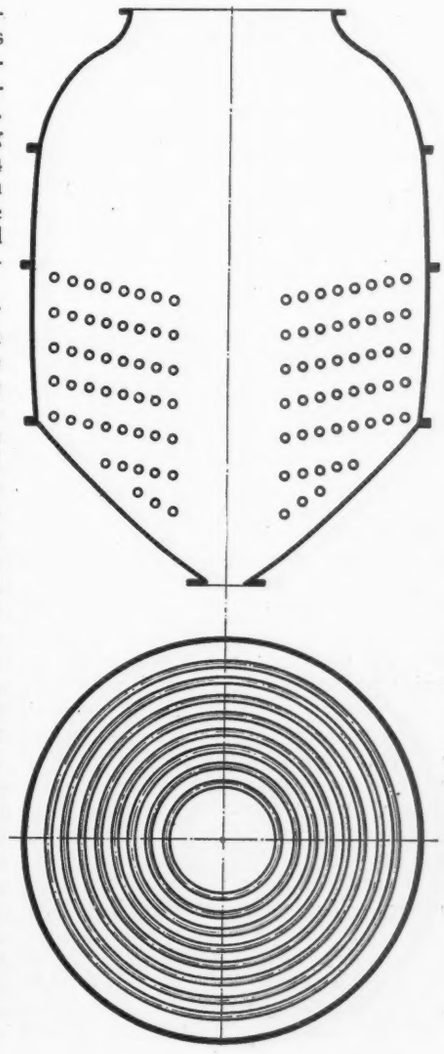
The syrup obtained from washing the raw sugar crystals goes separately through the same processes as the liquid and comes from the filtration process in various grades in the same manner as the liquor. The various grades are combined or reprocessed according to purity, strength, or color. Different methods of boiling must likewise be practiced to obtain different grades of refined sugar and syrup.

The bulk of boiling for evaporation and crystallization is done in a single-effect vacuum pan. Greater thermal efficiency could be obtained by evaporating in some pans, starting graining in other pans by using vapors from evaporating pans as the heating agent, and finishing graining in final pans utilizing the vapors from the intermediate pans. Complication of operations, cost of additional equipment, and required housing makes such a system impracticable. In boiling, the liquid is combined with a certain quantity of syrup which cannot be grained and therefore serves as a method for keeping the graining crystals in circulation and providing a reasonable flow in emptying the pan after crystallization is completed. In boiling a pan of liquor the first process is that of evaporation, in which circulation is very rapid and the steam demand very high. This is followed by a period of formation of crystals, which sometimes is hastened by seeding the pan; that is, injecting into the liquor, after evaporation, some very fine grained sugar. The final period is that of increasing the size of the crystals during which a small quantity of fresh liquor is taken into the pan from time to time as the massecuite, or mixture of syrup and crystals, becomes heavy so that circulation is retarded.

The time of boiling a pan of sugar varies greatly. Fine grain sugar can be boiled in 1¼ hours, an extra large grain sugar may require 5 hours, while remelt and soft sugars sometimes require as much as 20 hours. Due to the rate of evaporation at the beginning of boiling, the steam consumption is greatest at that period and gradually decreases during the process of crystallizing. A curve of rate of steam consumption on a pan of granulated sugar is roughly similar to the shape of the indicator curve of a steam cylinder. The peak consumption in this case is sometimes two and a half times the average throughout the cycle of the pan. In slower boiling sugars the relative height of the peak is much less.

There are two types of vacuum pans in general use. The coil type, shown in sectional elevation and plan in Fig. 1, is designed for the use of steam pressures ranging generally from 60 to 80 lb. gage. In diameter the pans are from 8 to 16 ft. with 10- and 12-ft. diameters predominating. The heating surface is of helical copper coils in a ratio of slightly more than one square foot of heating surface to one cubic foot of massecuite. The copper tubes usually are 4 in. in diameter. For the most effective use of the heating surface the length of coil is limited to about 200 times the diameter of the tube. In the larger pans this necessitates dividing a single coil into sections. In most pans there is a separate steam connection from an external manifold to each section of coil and a separate outlet for condensate. On some pans there are as many as 24 steam connections through the shell of the pan and as many condensate connections through

Fig. 1—Sectional plan and elevation of coil type of vacuum pan



the bottom. In the older refineries there is a trap on each condensate outlet, but in the more modern installations the condensate is drained to a single receiver for each pan.

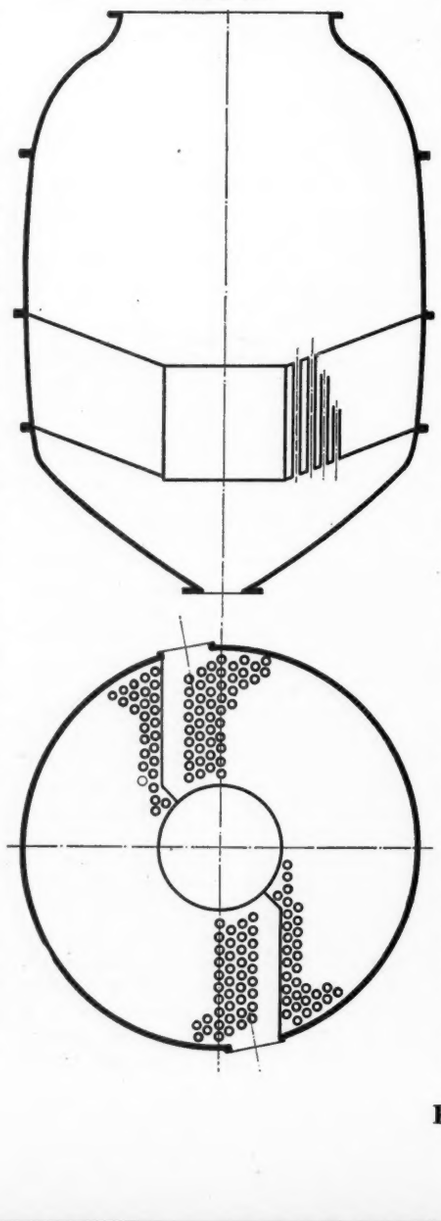
Due to its greater capacity for heating surface, thereby making it possible to boil entirely with exhaust steam, the calandria type is supplanting the coil type of pan. The calandria section is made up of a cast-iron ring between the upper and lower tube sheets, in which are expanded copper tubes. In contrast to the coil type, the steam is outside of the tubes and the massecuite circulation through the tubes; but, as in the coil type, the circulation is upward over the heating surfaces and downward through the center well. Usually there are two steam inlets. In some designs the steam is passed around the circumference in a chamber in the cast-iron ring with ports to admit the steam at various parts of the circumference. In other designs a space for the passage of the steam around the outer circumference is provided by omitting the outer row of tubes. Condensate water is drained through the bottom tube sheet and provisions are made for drawing off non-condensable gases, heavier gases from the bottom, and lighter gases from the top of the steam space.

There have been many different designs of calandrias, including the double and the floating types, but today the preference lies between the inclined type and the flat type. Fig. 2 shows in sectional elevation and plan the inclined type. The flat type is similar except that the tube sheets are horizontal instead of inclined. The heating surface in the calandria type generally is at a ratio of about 1.8 sq.ft. of heating surface to 1 cu.ft. of massecuite.

There is a wide variation of opinion among designers in regard to the ratio of the diameter of the tube to its length. There is one pan giving excellent results with 2-in. diameter tubes 6 ft. long, while one designer insists upon 5-in. diameter tubes for a length of 3 ft. 6 in. It is hoped that the future will develop a dependable method for measuring the velocity in tubes in service in order that some one ratio may be substantiated. More attention is being paid to the importance of high velocity of steam about the tubes in order to increase heat transfer. There are several arrangements of vertical baffles between the tube sheets, one of which is shown in plan in Fig. 2. For many years spasmodic attempts have been made to increase the rate of heat transfer by more rapid circulation of the massecuite. This is forced circulation obtained through the use of propellers. The great advance in recent years of the knowledge of propeller science has aroused greater interest in its use in sugar boiling and experimental installations are now being made.

There are many washings in a refinery, particularly in the bone char filters, which produce a large quantity of sweet water, a liquor with a very low sugar content. This provides an opportunity for the use of a multiple-effect evaporator. Not only does it have the advantage of using exhaust steam but it also makes a large return upon the investment. A refinery of a capacity of 2,500,000 lb. per day will do 4 per cent of its total evaporation in sweet-water evaporators. This means the use of about 66,000 lb. of steam. In a quadruple-effect, 1 lb. of steam will evaporate about 3.33 lb. of water where in a vacuum pan only about 1 lb. of water is evaporated. This means a saving of about 155,000 lb. of steam at a cost of possibly 30c. per 1,000 lb., or a daily saving of $46. Assuming 225 days of full melt a year, this means an annual saving of about $10,350, which is a good return on a fair-sized investment. The performance and problems of a sweet-water evaporator are the same as those of any hot-water evaporator with the exception of the item of scale. Sweet water forms scale on the tubes, but this can be greatly reduced by making the evaporator reversible and intermittently changing the direction of flow of the sweet water.

Fig. 2—Sectional plan and elevation of inclined tubular type of vacuum pan or calandria



Many refineries install triple- and even quadruple-effect evaporators for thickening a certain portion of the liquors before boiling in the vacuum pans. An ordinary refinery might thicken 25 per cent of their total liquor, removing about 20 per cent of the water in the liquor. Assuming conditions mentioned on the sweet-water evaporators this would provide a saving of about $16 a day, which would not be sufficient return upon the investment. There are some refineries fortunate enough to have sufficient quantity of one grade of liquor to make the evaporator profitable. Many refineries install evaporators for the purpose of increasing production without increasing vacuum-pan capacity.

The balancing of steam systems is a problem that frequently arises and is often expensive to attain. Not so many years ago refineries generated steam at a pressure sufficient to operate reciprocating engines, usually at about 125 lb. Process steam for use in vacuum pans was generally of 70 lb. pressure and was secured by passing the higher pressure steam through a pressure-reducing valve. The heating of water, liquor, and syrup, and the use of multiple-effect evaporators, provided a greater demand for exhaust steam than the engines supplied at from 5 to 10 lb. pressure and additional steam was blown into this system from the process system.

The electrification of all steam-driven auxiliaries and service equipment, as well as the installation of labor-saving machinery, increased the power load and consequently the production of exhaust steam which had to be blown to the atmosphere. At the same time the various processes have been improved, resulting generally in more efficient use of heat and thus reducing the demand for exhaust steam. In order to produce less exhaust steam, boiler pressures have been more than doubled, mixed-flow steam turbines bleeding into the process system have been installed, and small turbines for driving auxiliary equipment, designed to exhaust into the process system, have replaced electric motors. Still refineries have a tendency to become unbalanced in their steam systems.

The one logical remedy is to use more exhaust steam in vacuum pans, and for that reason refineries are converting coil pans into calandria pans. This usually results in faster boiling pans with greater peaks in steam consumption, especially when two or more pans start boiling at about the same time. These peak demands are becoming greater than the boiler houses can meet and they will have to be remedied either by a better schedule of pan cycles with a possible slight reduction in production or, possibly, by the use of steam accumulators.

Steam Waste—

An Unwarranted Loss That You Can Stop

By M. P. CLEGHORN
Professor of Mechanical Engineering
Iowa State College
Ames, Iowa

IT MUST be evident to even a casual observer as he passes through many small steam power plants that inefficiency is the rule. And one cannot fail to notice also in the food industries the inexcusable waste of heat that occurs in some of the heat processes used.

In the boiler room we often find low-set, poorly mounted boilers, with cracked and bulging furnace walls. The cold air passing through these settings is carrying heat up the stack about as fast as coal is shoveled into the fire door. The entire combustion equipment is often poorly designed or incorrectly installed. The management fails to see, unless forced to do so, the clouds of black smoke rolling from the stack.

Who would consider the storage of water in a tank, or its transportation in pipes, made of wire screen? Yet we find many heating retorts, cooking vats, and steam pipes with almost as little protection against loss of heat. A 4-in. bare pipe carrying steam at 100 lb. pressure, and 100 ft. long, will lose enough heat in 10 hours in heating the surrounding air to condense 1,000 lb. of steam. At 10 hours per day for 300 days per year the loss from this pipe alone would amount to 300,000 lb. of steam annually, equivalent to over 25 tons of coal. A good pipe covering would reduce this loss to one-tenth. What applies to pipes also applies to the outside of any heated surface, such as that of cookers.

The sizzling of a leaky joint is not music to the man who knows, and the words of the fellow who gets a drop of boiling hot water down the back of his neck from such a leak are not for gentlemen to hear. Yet how often do we find such leaks! A wicked man may not be able to pass through the eye of a needle, but a surprisingly large quantity of steam will pass through a hole no larger. The fact that a leak is out of sight makes it no less a loss. Boiler leaks within the setting, and leaky blow-off valves or cocks are common faults of this class.

Many small canning plants develop their own power by the use of steam engines and exhaust the steam into the atmosphere, using live or high-pressure steam for all the canning processes in the plant. Few realize that a small steam engine exhausts about 90 per cent of the heat that is supplied to it, and that this heat is still available for use.

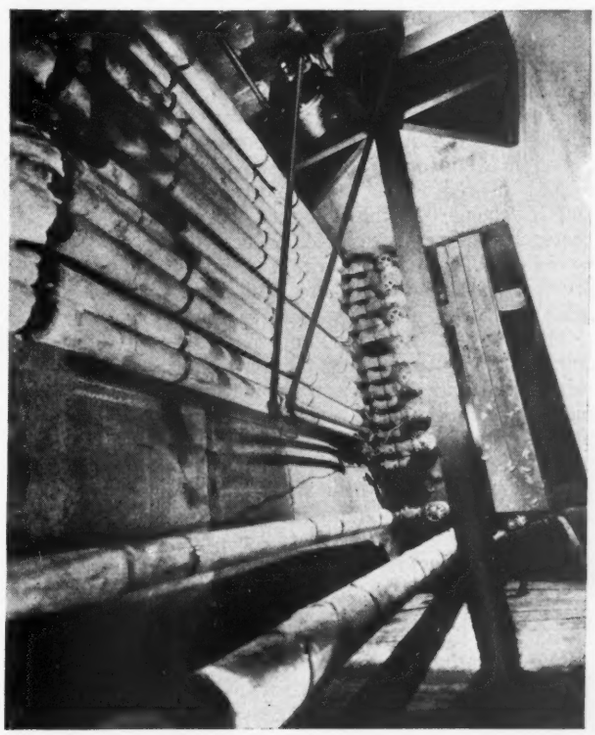
But there is another loss greater than some I have already mentioned, incurred by discharging hot, condensed steam to waste. This is pure condensed steam with no scale-forming salts in solution to foul the boiler, and contains a large quantity of valuable heat that should be returned to the boilers. Mention has been made of condensation in steam lines due to the heat radiation from the pipe. Whether covered or not, some condensation will occur, and this should be removed and returned to the boiler while hot. The canning process may be able to use this hot water as it comes in with the steam, at the same temperature as the steam, yet there are two objections to leaving it in the steam main: This water restricts the flow of steam in the main. Also, if too much of this water collects in the main it may lead to serious water hammer or pounding, with consequent danger of rupture.

Consider a cooking retort having a capacity of 1,000 No. 2 cans. The heating and cooking of this batch will require about 200 lb. of steam at 15 lb. pressure. Assuming eight batches per day, each retort will discharge about 1,600 lb. of condensed steam per day at a temperature of 250 deg. F. This, when discharged to the drain, means a waste of over 40 lb. of coal per day per retort. Ten retorts running 300 days will therefore waste about 60 tons of coal.

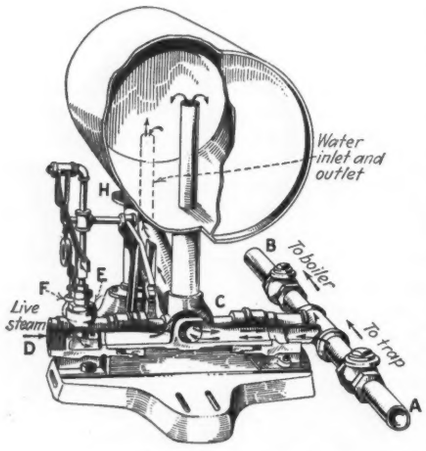
However, it takes the pulp cooking vats, such as catsup cookers, to waken the fireman and set the boilers into the harness for a stiff pull. Then it is that a heavy loss will occur, and more boilers will be needed on the line unless the hot condensed steam from the cooker coils is brought back to the boilers. To reduce 725 gal. of raw tomato pulp (one vat) to catsup requires about 4,500 lb. of steam, and about 900 lb. of this is demanded in the first 7 or 8 minutes. The temperature of this condensed steam in the heating coils would be that corresponding to the pressure of the steam—say 300 deg. F. Should this be carried back to the boiler without loss of heat, coal would be saved sufficient to heat 4,500 lb. of feed water from the well temperature to this 300 degrees.

Before this condensed steam can be disposed of in any way it must first be removed from the cooking device. It

In a pit below catsup cooking vats, where a hot water receiver is located, go drain connections, equipped with checks and cut-off valves. The large pipe in the foreground carries hot water to return trays over the boilers



must be removed completely as fast at it is formed and must be removed without the escape of steam. If allowed to back up in the cookers or heating coils, it will reduce the heating surface and interfere with the rapid circulation of the steam in the system, thus reducing effective heating. This in turn may either stop the cooking process or prolong it to the injury of the finished product. Removal usually is done with a steam trap. There are a number of types of traps on the market, any one



One type of return trap, which discharges hot water back into the boilers

of which, when in good condition, will remove the water without the escape of steam. The outlet from the trap is controlled by a float or bucket floating on the surface of the water in the body of the trap, or by expansion of a liquid, vapor, or metal element, or by tilting or tipping of the body of the trap due to weight of water collected. The latter type is called a tilting or bowl trap. Traps may also be classified as lifting or non-lifting. A lifting trap is designed so that it will force the water against a greater pressure than that in the line drained; a non-lifting trap is one which will not do so. For instance, we might wish to drain condensed steam from a heating main at 5 lb. pressure and discharge it into a feed water heater at 15 lb. pressure. A lifting trap would be required. To drain a high-pressure cooking coil into the same heater, a non-lifting trap could be used.

This suggests one way, and the most common way, of returning the hot water to the feed water heater, from which it may be pumped to the boiler by a feed pump. Should there be an insufficient quantity of exhaust steam from other sources to heat the feed water to the temperature corresponding to the pressure in the heater, then this method would be satisfactory, provided the traps are of sufficient size and number, and placed so as to receive the condensed steam from the coils without restriction.

One wasteful practice sometimes seen is discharge of high-pressure traps into a cistern or hot well open to the atmosphere. Condensed steam in a pipe carrying steam is at the same temperature as the steam. At 100 lb. gage pressure this is about 340 deg. F. When this water reaches atmospheric pressure, where the boiling point is only 212 deg. F., the heat representing the difference between 212 and 340 deg. is suddenly released and flashes enough of the water into steam to reduce the temperature of the remainder to 212. This flash steam escapes and carries heat with it.

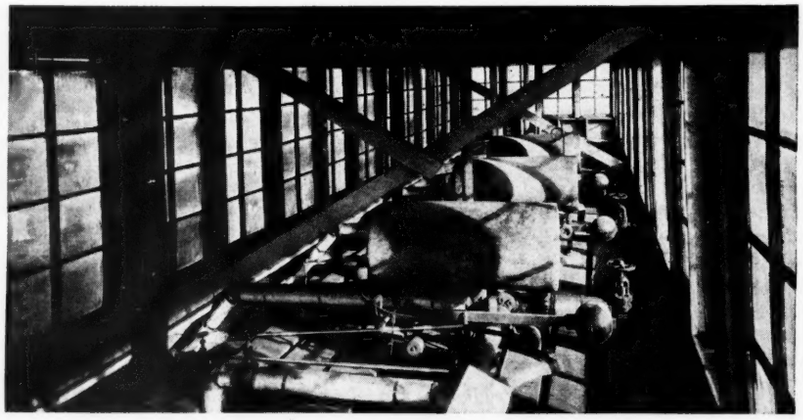
There remains one type of trap to be discussed: the return trap. It may be of the float type, but usually is of tilting or bowl construction. It is located above the boilers, receives hot water from other traps or receivers, and is designed to discharge directly into the boilers. The figure at the left shows a section of one make of return trap. The drum or closed tank is mounted as shown on a hollow trunnion or shaft, free to turn in packed joints. Pipe *A* connects with the source of water supply. Pipe *B* connects with boiler below water line. Each of these pipes carries a check valve opening toward the boiler. On the opposite end of the shaft is a live steam connection to the boiler. Valve *E* in this line, and vent valve *F* are controlled by a lever and counterweight which holds the tank in a level position when it is only partly filled. The vent must connect to a point where the pressure is equal to, or lower than, the pressure in *A*. With tank in level position the steam valve is closed and the vent valve open. This allows water to flow into tank from *A*, check valve in *B* holding boiler pressure back. With tank full it tips down onto bumping post *H*, levers close the vent *F* and open steam valve *E*. This admits full boiler pressure up middle pipe and onto surface of the water in tank and allows water to run by gravity into boiler through *B*, since now pressure in the trap and boiler are balanced. The check valve in *A* is now held shut by the high pressure in tank. When emptied down to required level the weight and lever again right the tank, close steam valve *E* and open vent valve *F*, and allow tank to fill again. If it is not desirable to vent trap back to hot-water supply it should be vented to feed water heater, where steam escaping from vent during filling period may be utilized.

It should be noted that hot water from cookers must be lifted into return trap. This may be accomplished with a pump, a lifting trap; or, if pressure in cookers is sufficient, this may be used to force water to the higher level. In the latter case, a closed tank or receiver is used into which hot water is allowed to gravitate from cookers. The bottom of this receiver is connected with the return trap above boilers, and as the vent valve on trap opens, pressure in trap is reduced enough to allow pressure in receiver to force water into trap.

How One Trap Is Used

As a return trap must act intermittently, it is necessary to have more than one so that one is available for filling while the other is discharging. The number required depends upon conditions. If the use of more than one trap is not feasible, a single trap may be used and a receiver placed above the one return trap and connected to it.

There are several rules to be followed in locating and connecting traps. First, there should be sufficient trap capacity. The drain traps or receivers should be located well below the lines to be drained and connected to the lines with pipe of sufficient capacity. Do not attempt to drain two lines of different pressure with the same trap. If one trap or receiver is used to drain two or more lines under the same pressure it should be located even further below the lines than necessary for draining one line only and each connection should be supplied with a good check valve. A return trap should be located six or more feet above the water line of the boiler and the connection should be large. This connection should not connect with the pump or injector line to the boiler, since



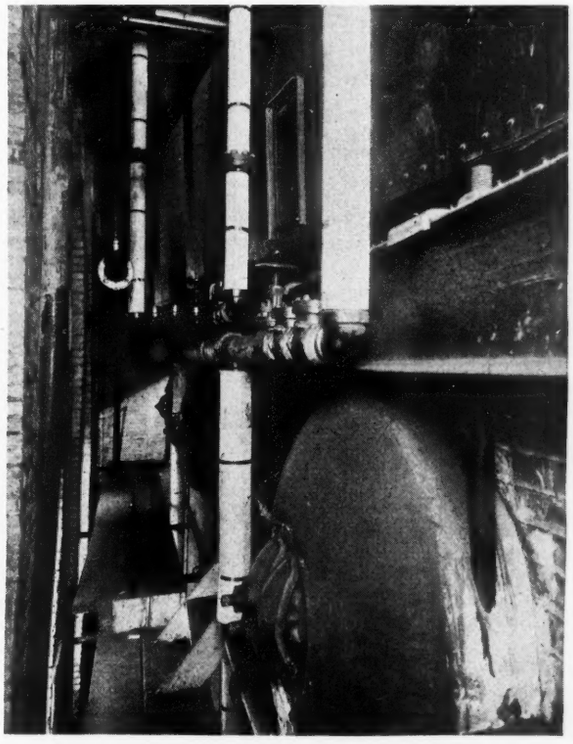
Three return traps in place in the monitor of a boiler house. The pipes rising through the floor at the right are supply lines, connected below the floor to a single line for the receiver in the pit. Pipes at the left carry water to the boilers

the pump action will interfere with the trap action. If another feed line direct to the boiler is not possible, then the connection may be made to the blowoff line and the boiler supplied that way. The pump may then be used at the same time if desired. The steam connection to the trap should be taken direct from the boiler and not from some main supplying steam to other equipment.

As an illustration of what may be accomplished in the way of savings, the Marshall Canning Co. plant at Marshalltown, Iowa, where I acted as consulting engineer during a revamping of the power end of that plant is an example. Before improvements were started, the boiler room contained two 200-hp. water-tube boilers, and one 250-hp. boiler of the same type. The brick settings of these boilers were in bad condition, with big cracks and bulges on the sides which admitted a great deal of excess air. They were hand-fired with Illinois No. 2 nut coal costing about $5 per ton. One test at 125 per cent of rating showed a boiler and grate efficiency of 53 per cent, with air entering the setting equal to 3.14 times the amount theoretically required for the fuel. Practically all the steam was used in cooking or cleaning, and the condensate was wasted to the sewer. Cold raw water was therefore supplied to the open heater and pumped to the boilers at a temperature of about 120 deg. F. The feed pumps were in poor condition and none too large for the plant. This plant contains, besides a great deal of other canning equipment, five 700-gal. tomato-pulp cooking vats and two other smaller ones. In the tomato season these use a large quantity of steam and the condensate was originally all drained out by bucket traps and wasted to the sewer. The pumpkin cooking equipment also was operated in the same inefficient manner.

The first improvement was to purchase a new 250-hp. water-tube boiler. All the old boilers were dismantled, and with the new one were all set 12 ft. from the floor, and equipped with natural draft chain grate stokers. The stoker grate area was proportioned for Iowa screenings coal of about 9,000 B.t.u. content per pound. Ash bins and basement were constructed below the boilers, and a steam jet ash conveyor was installed. Raising the boilers made it necessary to raise the roof of the building about 5 ft., and adding a new boiler required revamping the smoke breeching. All this was done while steam was being furnished to the canning department, except for about two weeks when the breeching was being enlarged and raised. At the conclusion of this first improvement a test on one of the larger boilers and stoker showed an efficiency of 73.4 per cent while using Iowa crushed mine-run coal costing about $3.83 per ton and operating at 158 per cent boiler rating. Since then the plant has operated satisfactorily on Iowa screenings costing about $3.50 per ton. This change resulted in a material reduction in cost of steam, and entirely stopped the discharge of black smoke from the stack.

The next improvement was to install return traps on the tomato-cooking vats and pumpkin cookers, and return all the condensed steam from these directly back to the boilers. It was decided to install one receiver below the cookers and drain all coils into this, using three return traps above the boilers. The problems to be met were as follows: Vats were in another building about 300 ft. from the boiler house, and with intervening buildings. They were on the ground floor, with no basement in which to place the receiver a sufficient distance below the coils. It was necessary, therefore, to construct a concrete-lined pit in the ground outside, and in ground that did not have drainage. This pit was made 8 ft. deep. In it was placed the receiver to which all coils were connected. From this receiver in the pit a 3-in. discharge line was extended out of doors and over the roofs of the other buildings to the boiler house. This line was connected to the three return traps having a combined capacity of 33,000 lb. per hour and located in the monitor of the boiler house at least 10 ft. above the boilers and about 38 ft. above the receiver in the pit. During the filling period these traps are vented to the heater and the steam thus exhausted helps to heat the feed water handled by the feed pumps.



At the rear of the boilers, feed lines from the three traps feed in at the blow-off connection. Connections are made in this way to allow for expansion

How Savings Were Made

The installation of this return-trap system has resulted in several savings. In the first place, the system is cleared of condensed steam much more thoroughly than before, and as a result the cooking time has been cut almost in two. With the old system it required 45 minutes to cook down one vat of the tomato juice or pulp; now it requires only 25 minutes. This not only increases the capacity of the catsup plant but it tends to make a better product. The condensed steam enters the traps at about 300 deg. F., thus saving both the pure water and the heat. The heat saved is equivalent to a substantially increased boiler capacity, and the pure water direct to the boilers takes a corresponding load off the feed pump and lessens scale trouble. The traps can hardly be heard when operating. Due to the distance and difficulties involved, the cost of the return-trap system installed complete with pipe covering and other accessories was rather high, reaching approximately $4,000. The system works perfectly, and while no tests have been made to determine the resulting saving over the old system it must be in the neighborhood of $10 to $14 per day during the catsup season. There are so many things involved in the saving that it would be difficult to determine it accurately.

One should not jump hastily to the conclusion that all improvements suggested should be made in every plant. The canning industry is largely a seasonal business and any expense involved for new equipment must be spread over a short period of operation. But there is no excuse for neglecting those things which will pay a return on the investment or improve the quality of the product.

THIS MONTH—

MAY

1—Millers' National Federation, Edgewater Beach Hotel, Chicago, Ill.

4—New England Industries New Products Day (New England Council), Hotel Copley Plaza, Boston, Mass.

9-10—Certified Milk Producers' Association of America, Monteleone Hotel, New Orleans, La.

10-11—American Spice Trade Association, Hotel Astor, New York, N. Y.

12—National Malt Products Manufacturers' Association, Hotel Pennsylvania, New York, N. Y.

13-17—National Cottonseed Products Association, Jung Hotel, New Orleans, La.

19-26—American Millers' Association (mills under 300-bbl. capacity), Watterson Hotel, Louisville, Ky.

23-26 — American Association of Cereal Chemists, Statler Hotel, Detroit, Mich.

23-27—National Confectioners' Association (convention and exhibition), Atlantic City Civic Auditorium, Atlantic City, N. J.

Hors d'Oeuvres

CUSTOMERS can candle their eggs as they buy them in a new automatic dispenser invented in Germany. A crank arrangement elevates the eggs from drawers and brings them in front of a candling light before delivering them.

•

COCA COLA has obtained the 1933 Chicago World's Fair concession for the sale of syrup drinks, and Orange Crush has obtained the concession for bottled soft drinks. Presumably, no official concession to Al Capone need be made.

•

BEES are still busy, despite the times, and the honey business generally is in good condition. Though exports have dropped, new uses and merchandising methods have led to sale of the present supply at fair prices. Maker of the "Honey-almond" candy bar has become the largest purchaser.

•

FLORIDANS may soon be amazed that another state produces citrus fruits. Amendment of quarantine regulations will now permit importation into Florida of California lemons and oranges, when washing and packing requirements are met. Previously, Florida has imported about 200 carloads of lemons annually from abroad.

•

CHEWING TIME for breakfast cereal has been cut by General Foods Corp. It has introduced "Grape-Nut Flakes" for those who like the flavor of the long-popular "Grape-Nuts" but who get plenty of jaw exercise during the day.

•

PEANUTS are now being sold with a brand name stamped on each shell, thus joining a long list of commodities that have found individual branding worth while.

What Food Men Are

Paper Milk Bottles—Higher Tariff

Canners—Surplus of Vegetables

Corn Institute Banned

ECONOMY-MINDED Philadelphia housewives, carrying "packages" of milk home from the grocery, have brought increased competition for dairies delivering door-to-door. Decreased distribution costs enable the newly organized Standard Dairies, Inc., to sell milk through American Stores Co. chain outlets two cents per quart below the delivered price. And the price to the producers is higher than that of other large dairies.

The return bottle problem, which usually robs sale through retail stores of most of its profit, has been eliminated by the use of sealed paper containers. Additional savings in transport weight and cost of refrigeration also are secured. All milk is delivered to stores in refrigerated trucks. Some door-to-door delivery of milk in the paper containers also has been begun, but at the regular retail price. With plenty of advertising behind the move, sales exceeded 25,000 qt. a few days after operation began. Introduction of the new containers led to protests by dairies using glass bottles. Municipal rulings, however, held that the container was perfectly sanitary and delivered full measure.

ALTHOUGH CANNERS are expected to make a decided cut in their production this year, the supplies of fresh vegetables and fruits will be as large as ever. The tender vegetables in the South were caught by the March freeze, but this had the effect of conserving the quality of the plants and did not cause a great loss. Peaches in Georgia and the Carolinas escaped the freeze and the Northern peaches were not far enough along to suffer. Vegetables in Texas, Louisiana, Mississippi, and Florida were threatened by a drought, but rains fell in time to save them.

Production forecasts by the Bureau of Agricultural Economics for certain crops follow: snap beans, slight increase; cabbage, 32 per cent decrease; Bermuda and creole onions, 27 per cent increase; green peas, 10 per cent increase; strawberries, 19 per cent increase; beets, 23 per cent increase; cucumbers, 5 per cent decrease; carrots, 19 per cent decrease; spinach, 36 per cent decrease; lettuce, 6 per cent increase; cantaloupes, 11 per cent decrease in the Imperial Valley and 20 per cent decrease in Florida; early Irish potatoes, 50 per cent decrease.

Canners are planning decreases in their output as follows: kraut, 12 per cent; tomatoes, 8 per cent; pickles, sweet corn and snap beans, about 40 per cent.

Much less canned goods is carried in stock now than at this time last year. The percentage decreases for some of the products follow: peas, 44 per cent; corn, 27 per cent; tomatoes, 40 per cent; green and wax beans, 32 per cent; peaches, 22 per cent; pears, 33 per cent; pineapple, 40 per cent.

CUBA will wipe out the domestic cane and beet sugar industries in the United States in nine years if imports of Cuban refined sugar continue to increase at the present rate of 134 per cent. Such was the plea made by domestic refining industries at a hearing of their petition for increased duty on refined sugar before the Tariff Commission on April 12.

American importers of refined sugar, in opposing the plea, pointed out that the decrease in earnings of four large refining companies in the United States during 1931 was only 18 per cent, as compared to an average decrease of 32 per cent for the food products industry as a whole. In answer to the refiners' contention that the expansion of the sugar refining industry in Cuba is detrimental to the interests of American capital and labor, the importers declared that there were less than 14,000 men employed in the sugar refining industry in the United States and that increased industrial activity in Cuba creates a market for American products.

ADVERTISING is selling canned foods. Reports on the National Canners' Association newspaper campaign in 69 cities now indicate real results, particularly where tie-in advertisements by local distributors also appear. Association copy, featuring quality, convenience, health, takes half a page. Advertisements of individual canners, jobbers, wholesalers, and retailers, stressing price, surround the association advertisement. At present, 385 retailers, 53 wholesalers, 48 canners, and 8 brokers, a total of 494, are using "tie-ins."

Many dealers have reported increases in sales volume of over 30 per cent. Well over 100,000 booklets discussing canned foods have been requested on coupons clipped from the advertising. Cumulative results of the campaign will not be apparent until final advertisements appear early in May. General feeling, however, is that the campaign has "clicked."

MEMBERS of the National Canners' Association in "good standing" may no longer have to meet claims or judgments from suits instigated by

Doing and Saying

Urged for Sugar—To Pay Claims for and Fruits—Advertising Pays—Sugar Standards

consumers for injury or illness alleged to be due to the eating of canned food. The association assumed that burden March 30 by extending its consumer complaint service to the payment of judgments and settlements in excess of $3,000 and not more than $25,000. To cover this service, $50,000 is to be transferred from the reserve fund to three trustees to be used at their discretion.

To benefit from this "complaint insurance" the canners must comply with new bylaws of the association regarding dues, follow its recommendations for the preparation of canned foods, and employ improved canning practices.

This new service follows a large increase in the number of unfounded claims against canners during the past two or three years. It is another step in the direction which the association's activities took in 1910 when the investigation of consumers' claims was inaugurated, and in 1923 when the association began to defend its members against such claims.

ANOTHER CONSENT DECREE came into being on April 16 when fifteen members of the corn products industry acquiesced to a federal injunction against alleged price fixing and the curtailment of production activities by the Corn Derivatives Institute. The injunction dissolves the institute and requires the defendants "to refrain from fixing prices, terms, concessions, and transportation charges; from causing uniform and simultaneous changes in prices; from manipulating prices to coerce any manufacturer to cooperate; from allotting customers, and from agreeing to refuse to quote freight rates except in accordance with the so-called basing point system." Denial of the charges was made by the defendants, but the decree was signed "to avoid the expense and delay of litigation" and "to avoid being in a position of antagonizing the government."

The Corn Derivatives Institute was organized in 1925 to collect, compile, and distribute information regarding production, prices, and general conditions prevailing in the industry. Practically all the large manufacturers were members.

BACTERIAL STANDARDS for sugar established last year by the National Canners' Association have proved highly effective in lessening the possibility of thermophilic contamination of canned foods from this source. For 1932, standards have been reissued having the same limits, but with several improvements in technique for the detection of flat-sour spores.

An outgrowth of work which established the relation between bacterial condition of sugar and thermophilic spoilage of non-acid vegetables, these standards were established to enable canners to test sugar bought upon specifications as to contamination and to provide a basis by which the association research laboratories could judge test samples sent in by members.

NO GUESSING at the size of potatoes and no arguments among sellers and buyers as to whether a "large" potato is really large, or merely a near-sighted packer's designation, will now be necessary. The Bureau of Agricultural Economics has instructed food products inspectors to make specific designations of sizes in potato grade certificates.

For the round varieties of potatoes, the size will be given in inches of diameter, and for the long ones it will be in ounces of weight. Ordinarily, the minimum, maximum, and average sizes found in lots inspected will be reported. Buyers desiring to protect themselves against delivery of potatoes which are just over the minimum or just under the maximum size specified should state the percentage under or over a certain size which they are willing to accept.

NO DECISION had been issued by the Department of Agriculture as to changes in substandard labels and in standards for canned goods at the time FOOD INDUSTRIES went to press. However, announcement of such changes will be forthcoming soon as a result of the hearing on proposed amendments of the regulations and standrads under the McNary-Mapes Amendment (FOOD INDUSTRIES, April, p. 145).

—AND THE NEXT

JUNE

6-10—Association of Operative Millers, Louisville, Ky.

14-16—National Macaroni Manufacturers' Association, General Bronk Hotel, Niagara Falls, Ont.

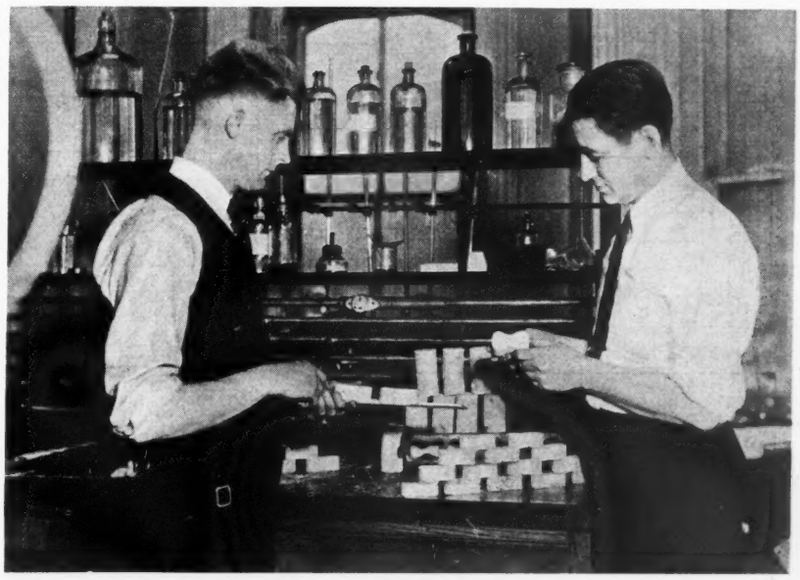
15-July 15 — International Bread-Making Exhibition (also macaroni products), National Fascist Federation of the Baking and Kindred Trades, Bologna, Italy.

19-21—New England Bakers' Association, Hotel Rockmere, Marblehead, Mass.

20-25—American Home Economics Association, Atlanta Biltmore Hotel, Atlanta, Ga.

27-30—Junior (West Coast) National Convention, American Society of Bakery Engineers, Ambassador Hotel, Los Angeles, Calif.

Do you know of any national convention that we have neglected to list? Your help in making this calendar complete will be appreciated.



It May Make Home, Sweet Home

Addition of sugar to lime-sand mortar increases its tensile strength, according to experiments reported to the American Chemical Society by Gerald J. Cox (left) and John Metschl, of Mellon Institute. Investigating new uses for sugar under the Sugar Institute, Inc., fellowship, Cox and Metschl found that sugar equal in amount to 6 per cent of the quicklime increased tensile strength 60 per cent, indicating a possible new outlet at present prices.

THE BUSINESS PAGE

Bill Would Make Canners Eligible for Loans

PRODUCERS of canned foods would be eligible for loans from the Reconstruction Finance Corp. under an amendment proposed by Senator Steiwer, of Oregon, on behalf of the fruit canners and salmon packers of his state. The Senator's proposal presents to the canning industry the question of whether further access to government funds by individual canners would be to the best interest of the industry as a whole. The opinion is expressed in some quarters that such loans would tend to encourage canners to pack more than they can market, thus further disturbing an already weak price structure.

No action has been taken by the National Canners' Association on the bill, which would empower the Finance Corporation to make loans up to two-thirds of the market value of canned foods when producers are unable to obtain adequate credit from other sources. Such loans would be secured by warehouse receipts.

Preserve Census Taken

TO COLLECT reliable data by which trends in the manufacture of preserves, jellies, and allied products may be determined, the Department of Commerce is making its third annual census of production in that branch of the food industry. Figures on the quantity and grade of the different kinds of preserves, jams, and jellies, their invoice value, and the types of containers used will be obtained.

Business Hopeful

Determined efforts to balance the national budget, continued decrease of hoarding, of bank suspensions, and of borrowings from Federal Reserve by member banks, and indicated (though belated) moves by banks to extend credit give rise to prayerful hope that business conditions are convalescing.

The Business Week index of general business activity has moved upward to reach 58.3 per cent of normal for the week ending April 16. For the week ending March 19, this index stood at 56.9.

General commodity and food prices, as reported in a weighted price index, have been fluctuating considerably during the past month. After showing encouraging improvement they suddenly weakened during the week ending April 23 to show a decrease of 0.85 and 3.0 per cent, respectively, as compared with those for the week ending March 19. Grain price net gain is 4.54 per cent.

Purchasing capacity of wage earners and low salary groups has undergone no material change during the past month. A. & P. tonnage sales for March, 1932, were 5.90 per cent lower than for March, 1931. During February, 1932, they were 6.09 per cent below 1931 sales for the same month.

Food Industry Ranks High In Investment Class

ONLY FOUR industries were ranked in the "fair to good" class in a compilation issued April 22 by Moody's Investors' Service, but food products was among the four. The others were electric power and light, manufactured gas, and telephones. Five other industries were rated "fair," can manufacturing being one of them. With it were chemicals, electrical equipment, natural gas, and tobacco.

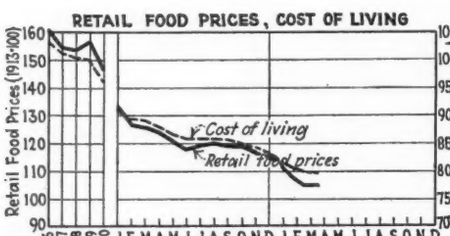
Meat packing and sugar industries did not fare as well as the food products industry in general. They fell in the "poor to fair" classification.

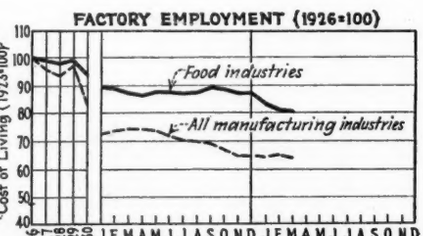
Tea Imports Increase

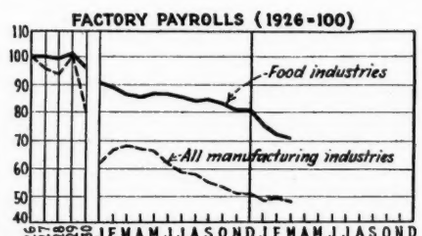
TEA IMPORTS into the United States showed an increase of almost five per cent during the past eight months, compared to the same period a year ago, according to the Department of Agriculture. The total imports were 64,813,897 lb., of which about two-thirds was black tea. The increase in the preference for black tea has been attributed to economy budgets.

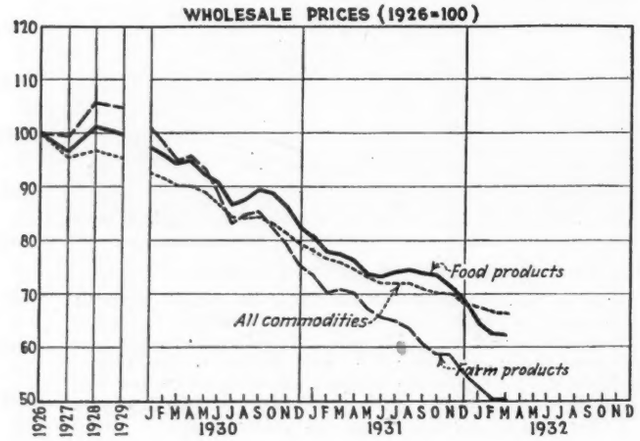
Basis for the Curves

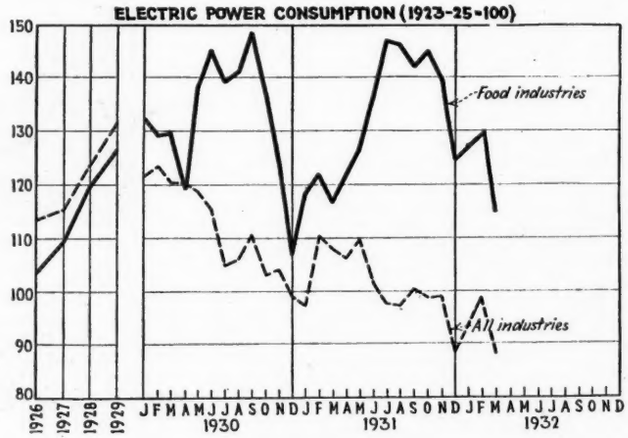
Retail food prices, factory employment, factory payrolls and wholesale prices are based on indexes of the Department of Labor. Cost-of-living index is that of the National Industrial Conference Board. Electric power consumption figures are furnished by *Electrical World*.


RETAIL FOOD PRICES, COST OF LIVING
Retail Food Prices (1913=100)
Cost of Living (1923=100)
Cost of living
Retail food prices
1926 1927 1928 1929 1930 J F M A M J J A S O N D J F M A M J J A S O N D
1931
1932


FACTORY EMPLOYMENT (1926=100)
Food industries
All manufacturing industries
1926 1927 1928 1929 1930 J F M A M J J A S O N D J F M A M J J A S O N D
1931
1932


FACTORY PAYROLLS (1926=100)
Food industries
All manufacturing industries
1926 1927 1928 1929 1930 J F M A M J J A S O N D J F M A M J J A S O N D
1931
1932

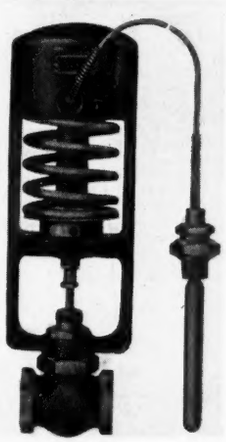

WHOLESALE PRICES (1926=100)
Food products
All commodities
Farm products
1926 1927 1928 1929 J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1930
1931
1932


ELECTRIC POWER CONSUMPTION (1923-25=100)
Food industries
All industries
1926 1927 1928 1929 J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1930
1931
1932

NEW EQUIPMENT FOR FOOD MANUFACTURERS

New Automatic Temperature Regulator

Greater sensitivity to changes in temperature is claimed for the automatic temperature regulator recently put on the market by Taylor Instrument Cos., Rochester, N. Y. One of the factors in the flexible operation of this instrument is the elimination of friction in the valve sleeves and bellows connections. Another factor is the small size and thin wall of the stainless steel bulb which allows quick transmission of temperature changes to the gas or liquid in the connecting copper



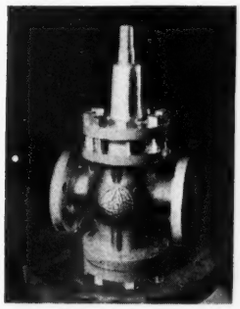
tubes and gives direct movement to the double seamless bellows.

Such direct response to temperature changes is reported to result in the prevention of a lag in the movement of the valve stem in relation to the temperature to which the bulb is subjected. The elimination of this lag in valve movement according to changes in temperature is of much importance when such an automatic type of regulator is used in connection with operations such as pasteurizing milk in small barrel-type units, heating water for vat pasteurizer circulating systems, drying-room control, and bottle washing.

Heavy-Duty Reducing Valve

Long, trouble-free performance at high temperatures and pressures obtains in the use of a reducing valve announced by the Mason Regulator Co., 1190 Adams St., Boston, Mass., according to the manufacturer.

The valve body is cast of chrome-molybdenum steel and is suitable for initial pressures up to 600 lb. per square inch at total temperatures of 750 deg. F. The main and auxiliary valves are made of



Nitralloy, which resists wire drawing. Other moving parts are machined from stainless steel.

The valve is designed to provide reduced flow turbulence and wide pressure ranges.

Electric Coffee Roaster

A delicate cup flavor and low roasting losses are claimed for coffee roasted in the Talbutt roaster manufactured by the McCormick Electric Roaster Sales Corp., Baltimore, Md.

These manufacturer's claims are based upon better control of temperature which the electric heater provides for. Also the absence of a forced current of air through the roasting cylinder gives more even roasting and permits the coffee to retain its flavor and aroma strength to a greater extent than when roasted by coal or gas, according to the results of the maker's tests. This intrinsic value is reported to amount to as much as 4 to 5c. per pound and to be due to the absence of combustion impurities in the roasting cylinder and to the retention of a higher percentage of coffee bean oil.

Although this roaster has been developed for coffee roasting it has been used successfully on an experimental basis to roast cocoa beans, nuts and breakfast cereals, and for drying purposes. It is likely to find special application in research laboratories where unusual roasting conditions are desired and in localities where the rates for current from water-power plants are low.

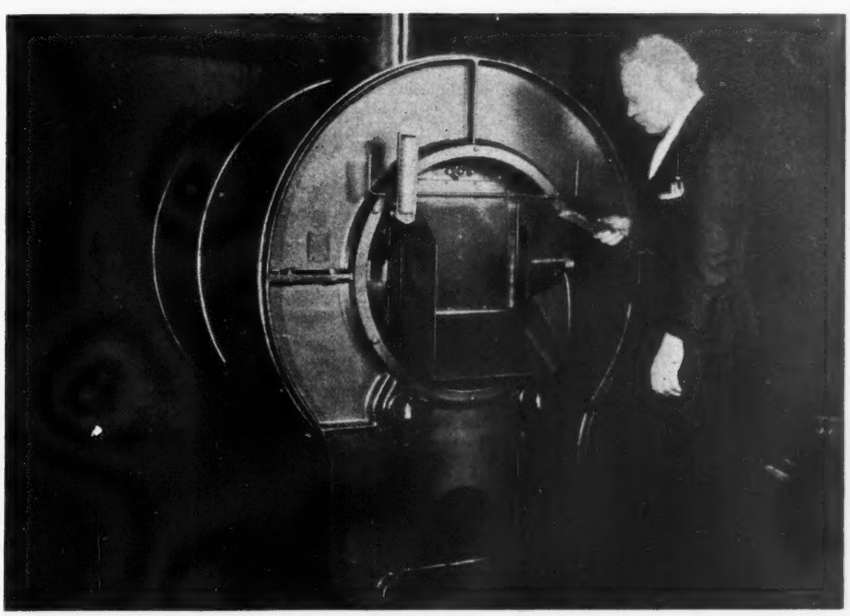
Steam Vacuum Refrigerator Reduces Cooling Costs

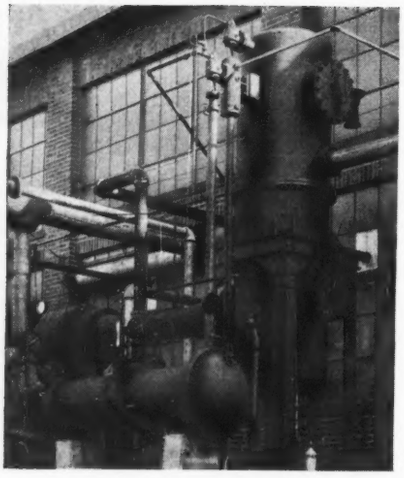
In industries where large quantities of water have to be maintained at low temperatures, a steam-operated vacuum refrigerator developed by the Foster Wheeler Corp., 165 Broadway, New York, N. Y., is reported to be extraordinarily economical. It is especially well adapted to use in dairy industries for cooling milk, and it is suitable for air conditioning in industrial plants.

The system operates on the principle of "flash" evaporation. The water to be cooled is piped into a chamber in which a high vacuum is maintained by a steam-operated thermo compressor. The vacuum causes the water to boil so that a portion of it is evaporated. This vapor, which absorbs latent heat of evaporation, is removed, and the temperature of the remaining water is reduced to a point corresponding to the absolute pressure of the chamber. Thus, the water—brine may also be refrigerated—is cooled without the use of a refrigerating medium.

The thermo compressor discharges into a high vacuum condenser which is served by a small two-stage jet air pump. Two tail pumps are provided, one for removing the condensing water from the condenser and one for removing the cooled water from the flash chamber.

Assuming that a pound of water at a temperature of 55 deg. F. is introduced into a flash chamber in which an absolute



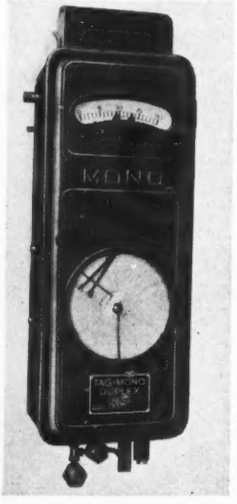


pressure of 3 in. of mercury is maintained, less than 1 per cent of the water will be vaporized and the remainder will be cooled to 45 deg. F.

The unit shown in the illustration cools water for process work and has a capacity equivalent to 75 tons of refrigeration per day.

Flue Gas Analysis Made By Indicator-Recorder

Better combustion control and, consequently, more efficient furnace operation, are said to be made possible by the use of the Tag-Mono carbon dioxide indicator-recorders, placed on the market by the C. J. Tagliabue Manufacturing Co., Park and Nostrand Aves., Brooklyn, N. Y. Two types of recorder are available. The duplex type, shown in the illustration,



records both the quantity of carbon dioxide and of unburned gases passing up the flue. The single type records carbon dioxide only.

Analysis of the gases is made chemically, and the indicating and recording is performed electrically. The apparatus consists of two main parts, the instrument itself and a motor-driven caustic pump. All of the analyzing apparatus is contained in an attractive metal case, at the top of which is a large illuminated indicating dial.

One charge of caustic potash will last for a period of from 10 to 12 weeks.

THE MANUFACTURERS OFFER

Sealing Caps — A 24-page, pocket-size pamphlet illustrating and describing the sealing and opening features and applications of the Darling Closure and Opener is furnished by the Crown Cork & Seal Co., Baltimore, Md. The publication also deals with sealing machines.

Monel Metal and Nickel—The mechanical and technologic properties, physical constants, and applications of Monel, nickel and nickel alloys are listed in a loose-leaf, pocket-size pamphlet of the International Nickel Co., Inc., 67 Wall St., New York, N. Y.

Pasteurizer—What "lies beneath the surface" of the Class K twin coil pasteurizer is the subject of a large 14-page folder leaflet of the Cherry-Burrell Corp., 427 West Randolph St., Chicago, Ill. The pasteurizer is of the tank type.

Rotary Dryers—The several types of drying equipment made by the Louisville Drying Machinery Co., Louisville, Ky., are pictured and their construction features and applications are given in the 32-page general catalog of the company. The continuous filter, continuous screen, screw type dewaterer, and inner tube suspension are also described.

Pyrometer Controllers—Catalog No. 2050 of the Bristol Co., Waterbury, Conn., gives the applications of the company's pyrometer controllers and describes and illustrates them. Schematic wiring diagrams also are given.

Welding Fittings — The welding heads, ells, sleeves, and saddles manufactured by the Midwest Piping & Supply Co., Inc., 1450 South Second St., St. Louis, Mo., are announced in a leaflet which gives specifications, sizes, prices, and characteristics of the fittings.

Box Stitchers—The new Monitor narrow stitching head is described and the applications of Monitor machines are illustrated in a folder leaflet of the Latham Machinery Co., 1143-1153 Fulton St., Chicago, Ill.

Variable Speed Transmission—In its 74-page attractively bound, well-illustrated Catalog No. 99 the Reeves Pulley Co., Columbus, Ind., explains how its equipment gives infinite variations in speed regulation of machinery. Complete construction details, methods of remote and automatic speed control, and applications are included.

Pans, Pails, and Dippers—The characteristics, sizes, gages, and prices of the line of Nesco Monel equipment manufactured by the National Enameling & Stamping Co., Inc., 346 West Kinzie St., Chicago, Ill., are furnished in a folder leaflet of the company.

Centrifugal Fans—In its Bulletin No. 386, B. F. Sturtevant Co., Hyde Park, Boston, Mass., describes and illustrates its new centrifugal compressors and gives rating tables and performance curves for the machines. The company's catalog No. 370 deals in a like manner with the Sturtevant convertible multivane fans.

Electrical Equipment—Catalog No. GEA-606C entitled "Industrial Control," General Electric Co., Schenectady, N. Y., devotes 196 pages to illustrations and specification details of its industrial electric equipment.

Power Transmission — Pitter one-way clutches and speed reducers of the heliocentric and revocentric types are described in an illustrated leaflet folder of the Universal Gear Corp., 327 South La Salle St., Chicago, Ill.

Air Conditioning—Abstract No. 1, Niagara Blower Co., 6 East 45th St., New York, N. Y., gives one of Erskine Engineering Series for power-plant engineers, executives, and students. A Bulkeley psychrometric chart for temperatures between zero and 200 deg. F. is included.

Vacuum Pumps—Bulletin No. 149-A is devoted to illustrations, descriptions, and specifications of Stokes high-vacuum pumps. F. J. Stokes Machine Co., Olney P. O., Philadelphia, Pa.

THE GOVERNMENT PUBLISHES

DOCUMENTS ARE AVAILABLE *at prices indicated from Superintendent of Documents, Government Printing Office, Washington, D. C. Send cash or money order; stamps and personal checks not accepted. When no price is indicated pamphlet is free and should be ordered from bureau responsible for its issue.*

Cream-Standardization Tables, by O. E. Williams. U. S. Department of Agriculture, Circular 199; 5 cents. Tables of standards to facilitate calculation for various grades of milk.

Tomato Storage, by R. C. Wright and others. Department of Agriculture, Technical Bulletin 268; 15 cents. A discussion of the effect of temperature on storage and ripening.

Wheat, Flaxseed, and Soybean Tests. Department of Agriculture, Miscellaneous Publication 140; 10 cents. Describes protein tests for wheat and oil tests for flaxseed and soybeans.

Coffee Industry in Colombia. Bureau of Foreign and Domestic Commerce, Trade Promotion Series 127; 15 cents.

International Trade in Macaroni Products, by George J. Carr. Bureau of Foreign and Domestic Commerce, Trade Information Bulletin 788; 10 cents.

Employment of Women in Slaughtering and Meat Packing, by Mary E. Pidgeon. Women's Bureau, Bulletin 88.

Intoxicating Liquors. Bureau of Industrial Alcohol, pamphlet; 20 cents. Statistical review of industry as of December, 1931.

Lighting Code. U. S. Bureau of Labor Statistics, Bulletin 556; 15 cents. For factories, mills, and other work places.

Rice Products for Feeding, by E. W. Sheets and A. T. Semple. U. S. Department of Agriculture, Miscellaneous Publication 132; 5 cents.

Boron in Irrigation Waters, by Carl S. Schofield and L. V. Wilcox. U. S. Department of Agriculture, Technical Bulletin 264; 20 cents.

Census Data. Printed pamphlets giving for commodities and groups of commodities the final returns on the census of industrial operations in 1929 are now available for the majority of the industries covered by the Census of Manufactures for that year. Corresponding reports for the Census of Distribution are appearing by industries in preliminary form. Final printed pamphlets from the Distribution Census are available only to a limited extent by states; not yet by industries.

Proximate Composition of Fresh Fruits. Charlotte Chatfield and Laura I. McLaughlin. U. S. Department of Agriculture, Circular 50. Revision to October, 1931, of publication issued December, 1928; 5 cents.

Alaska Salmon Statistics, by W. H. Rich and E. M. Ball. Bureau of Fisheries, Bulletin 7; 20 cents. Part III, relating to Prince William Sound, Copper River, and Bering River operations.

Price Sources. Commerce Department, 320-page cloth-bound volume; $1.10. An index of commercial and economic publications containing commodity market prices.

CONSTRUCTION NEWS

PROPOSED WORK AND BIDS ASKED

Bakery—Freihofer Baking Co., Union Blvd., Allentown, Pa., plans to rebuild plant destroyed by fire. Estimated cost to exceed $40,000. Maturity indefinite.

Bakery—H. C. Wartham c/o Butter Nut Bread Co., Texarkana, Tex., will soon receive bids for a 1 story, 85 x 140 ft. bakery at 10th and State Line. Witt, Seibert & Halsey, Texarkana, are architects.

Beverage Products Plant—California Raisin Products Corp., Fresno, Calif., leased old Fresno brewery and will remodel and install electric refrigeration plant and bottling equipment.

Brewery—Fort Edward Brewery, Fort Edward, N. Y., plans reconstruction of brewery destroyed by fire. Estimated cost to exceed $150,000. Maturity indefinite.

Canning Plant—H. J. Heinz Co., Erie St. S., Leamington, Ont., plans a 2 or 3 story addition to canning plant. Estimated cost $250,000. Private plans.

Cheese Plant—Kraft-Phoenix Cheese Co., 400 Rush St., Chicago, Ill., plans construction of a 2 story cheese plant at Boston, Mass., also 3 story addition to plant on Battery St., San Francisco, Calif. Estimated cost $40,000 each. Private plans.

Creamery Plant—Golden State Co., Ltd., 425 Battery St., San Francisco, Calif., plans construction of a creamery plant at San Pablo Ave., Richmond. Estimated cost $60,000. Private plans.

Creamery Plant—Knowlton Creamery, c/o S. E. Knowlton, 1415 West Summit St., San Antonio, Tex., will soon receive bids for a 2 story creamery plant at Fredericksburg Road. Estimated cost $45,000. L. Harrington & Co., Builders Exchange Bldg., San Antonio, are architects. Machinery and equipment will be purchased and installed.

Creamery and Ice Cream Plant—Sterling Milk Co., 316 North Western St., Oklahoma City, Okla., plans a 2 story, 80 x 100 ft. creamery and ice cream plant on Western St. Estimated cost $60,000 and $100,000 respectively. Private plans.

Dairy Addition — Dewhirst Dairy, Madison Ave., Bridgeport, Conn., completed plans for a 1 and 2 story addition to dairy plant. Estimated cost $40,000. Fletcher Thompson, Inc., 1336 Fairfield Ave., Bridgeport, is architect.

Dairy and Milk Depot—Lerad Realty Corp., c/o S. Adler Milk Co., 2797 Webster Ave., New York, N. Y., plans addition and alterations to dairy and milk depot at 453 East 133rd St.

Dairy and Pasteurizing Plant — Donlands Dairy, 120 Donlands Ave., Toronto, Ont., plans a 1 and 2 story addition to dairy and pasteurizing plant. Estimated cost $40,000. E. G. Wilson, 42 Langley Ave., Toronto, is architect.

Dairy Plant Equipment—Kaukauna Co-Operative Dairy, P. Lorenz, Pres., Kaukauna, Wis., receiving bids for equipment for dairy plant in building to be remodeled.

Distribution Plant, Etc.—Sheffield Farms Co. Inc., 524 West 57th St., New York, N. Y., will soon award contract for a 2 story distribution plant, office building, etc., at Union City, N. J. Estimated cost $40,000. George Willaredt, 411 23rd St., West New York, N. J., is architect.

Grocery Warehouse—Kroger Grocery & Bakery, 810 Northwest Fourth St., Oklahoma City, Okla., will soon award contract for a 1 story warehouse. Estimated cost $150,000. Private plans.

Market Building—City Council, New Orleans, La., will soon award contract for construction of a 1 story 40 x 190 ft. public market building including electrical refrigeration equipment and other modern improvements on Orleans St. Estimated cost $50,000. S. S. Stone, Jr. & Co., Masonic Temple Bldg., New Orleans, are architects.

Macaroni Manufacturing Plant—General Importing Macaroni Manufacturing Co., 63 Court St., Middletown, Conn., will soon award contract for a 2 story, 40 x 95 ft. addition to macaroni manufacturing plant. Estimated cost $40,000. C. E. Segerberg, 438 Main St., Middletown, is architect.

Produce Terminal—New York, New Haven & Hartford R.R., New Haven, Conn., plans extensive remodeling of freight houses and sheds for produce terminal at Columbus Ave., Springfield, Mass. E. E. Oviatt, New Haven, Ch. engr. J. Lepovelsky, 58 Narragansett St., Springfield, lessee.

Cold Storage Plant—City Ice & Fuel Co., 6611 Euclid Ave., Cleveland, O., plans construction of a cold storage plant at Elyria. Estimated cost to exceed $40,000.

Ice, Cold Storage and Refrigeration Plants—J. J. Harpey, Hitchcock, Tex., acquired cold storage and refrigeration plants at Hitchcock, Alta Loma, Arcadia and Algoa, also ice manufacturing plant at Hitchcock. Surveys will be made for improvements.

Ice Manufacturing Plant—Rubel Coal & Ice Co., Fulton St. and Waverly Pl., New York, N. Y., having sketches made for alterations to 2 story, 66 x 97 ft. ice manufacturing plant at St. Anns Ave. and 159th St. A. H. Eccles, 41-42 29th St., Long Island City, is architect.

Ice Plants—Consumers Ice Co., Tyler, Tex., plans construction of a 60 ton ice plant at Muskogee, also two 40 ton plants, one at McAlester and one at Sapulpa, Okla. Work will be done under the supervision of George E. Wells Inc., Security Bldg., St. Louis, Mo., Engrs.

Refrigeration Warehouse — Swift & Co., Packers and Exchange Aves., Chicago, Ill., plans construction of a refrigeration warehouse at Erie R.R. tracks, Elmira, N. Y. Estimated cost $40,000.

Flour Mills—T. Dexter & Son, Beaufort St., London, Ont., plans to rebuild flour mill including electrical equipment recently destroyed by fire. $50,000.

Grain Elevator—Allied Mills, Inc., J. B. De Haven, V. Pres., 29th and B. Sts., Omaha, Neb., plans to rebuild grain elevator and mill destroyed by fire. Loss $300,000.

Grain Elevator—Albany Port District Commission, Albany, N. Y., received lowest bid for construction of a grain elevator, 2,500,000 bu. capacity from James Stewart Corp., 343 South Dearborn St., Chicago, Ill. $689,690.

Grain Elevator Addition—Canada Malting Co., Royal Bank Bldg., Toronto, Ont., plans addition to grain elevator on Bathurst St. Estimated cost $100,000. John S. Metcalfe Co. Ltd., 460 St. Helen St., Montreal, Que., are architects. Conveying equipment will be required.

Fish and Fish Products Plant—Nova Scotia Sea Foods, Inc., 500 5th Ave., New York, N. Y., acquired Robinson Glue Co. plant at Canso, N. S., and purchasing equipment for fish and fish products. Contract awarded for addition and alterations to wharf to S. W. Hagerty, Monastery, N. S. Estimated cost to exceed $50,000.

Poultry Market and Slaughter—Twenty Seven Oregon St. Corp., 315 5th Ave., New York, N. Y., plans construction of a 1 story, 44 x 60 ft. poultry market and slaughter house at Borden Ave. and 46th St. D. Comyns, c/o owner, is architect.

Storage Building — Trunz Pork Stores, 25 Lombard St., Brooklyn, N. Y., having sketches made for a 3 story, 60 x 78 ft. storage building at Lombard St. and Kingsland Ave., also foundation and alterations to another 2 story building. Estimated cost to exceed $50,000. Almendinger & Schlendorf, 11 Hanover Pl., Brooklyn, are architects.

CONTRACTS AWARDED

Bakery Addition—National Biscuit Co., 449 West 14th St., New York, N. Y., awarded contract for an 11 story addition to bakery at 500 West 16th St. to Turner Construction Co., Graybar Bldg., New York. Estimated cost $500,000.

Bakeries—United Soviet Socialist Russia—c/o Amtorg Trading Corp., 261 5th Ave., New York, N. Y., will build kitchens, including bakeries, etc., 30,000 meals daily capacity in Leningrad district. Work will be done by day labor.

Bottling Plant—Canada Dry Ginger Ale Inc., 423 East Eighth St., Los Angeles, Calif., awarded contract for a bottling plant at Loma Vista and District Blvd., to W. P. Neil Co., 4814 Loma Vista Ave., Los Angeles. Estimated cost $150,000. Maturity July 1.

Bottling Plant—Coca Cola Bottling Works, Tyler, Tex., will build a 1 and 2 story plant. Most of work will be done by day labor. Subcontracts for materials and equipment let. Estimated total cost $32,000.

Plant — Punch Dry Ltd., 40 Kelvin Ave., Toronto, Ont., awarded general contract for construction of a 2 story plant for making soft drinks at York to S. F. Stinson & Son, 422 Hopewell Ave., Toronto. Estimated cost $50,000.

Dairy Plant—Hamilton Co-Operative Creameries, c/o H. W. West, 21 Main St. E., Hamilton, Ont., awarded general contract for construction of a 2 story dairy plant to George T. Evans, Federal Bldg., Hamilton. Estimated cost $45,000. Other contracts awarded.

Dairy Plant—Sheffield Farms Co., 524 West 57th St., New York, will build a 2 story dairy plant at Lowville. Estimated cost to exceed $40,000. Work will be done by day labor. Maturity late summer.

Dairy Plant — J. Weissglass, 2014 Forrest Ave., Elm Park, S. I., N. Y., awarded contract for construction of a 1 story dairy plant including pasteurizing, creamery and bottling plants, etc., at Mariners Harbor, S. I., to State Builders Inc., 845 Broad St., Newark. Estimated cost $40,000.

Ice Cream Plant—J. M. Horton Ice Cream Co. Inc., 205 East 24th St., New York, N. Y., awarded contract for construction of a 1 story, 100 x 100 ft. ice cream plant at Middletown, N. Y., to Enos Construction Co. Inc., 464 5th Ave., Brooklyn. Estimated cost $40,000.

Ice Cream Manufacturing Plant—Owner c/o Towner & Sellew Associates Inc., 363 Main St., Middletown, Conn., awarded contract for a 1 story, 50 x 70 ft. ice cream manufacturing plant on Saybrook Road to J. H. Mylchreest, 50 Brainerd Ave., Middletown.

Milk Condensing and Canning Plants, United Soviet Socialist Russia—United Canned Milk Industry, c/o Amtorg Corp., 261 5th Ave., New York, N. Y., will build milk condenseries and canning plants at Bashkiria, Mardovian, Aulonomaus Area and Western region. Each exceeds $1,000,000. Work will be done by technical aid contracts.

Milk Plant (Condensed)—Gordon Baking Co., LaGrange, Ind., will build a condensed milk plant. Estimated cost $100,000. Private plans. Work will be done by owner's forces. Equipment will be required.

Cocoanut Products Plant — El Dorado Oil Works, Third and University, Berkeley, Calif., awarded contract for construction of a cocoanut products plant on Adeline St., Oakland, to Barrett & Hilp, 918 Harrison St., San Francisco. Estimated total cost $750,000.

Food and Extract Plant—Hoyt Bros., 100 Shipman St., Newark, N. J., awarded contract for an 8 story, 75 x 85 ft. addition to plant for the manufacture of extracts, foods, polishes, cosmetics, etc., to Fassler Construction Co., Hill St., Newark. Estimated cost $150,000. Structural steel contract let to Passaic Steel & Iron Co., East Rutherford.

Sugar Refinery—Fellsmere Sugar Co., Fellsmere, Fla., will build a 1 story addition to cane sugar refinery, by day labor.

Cold Storage Plant and Bakery—Department of Mental Hygiene, Capitol, Albany, N. Y., awarded contract for construction of a cold storage plant and bakery at Harlem Valley Hospital, Wingdale, to Arctic Engineering Co., 123 White St., New York, $43,250.

Ice Plant — Genese Coal & Ice Co., Flint, Mich., awarded contract for construction of a 1 and 2 story ice plant, 65 ton daily capacity on Phelon St., Saginaw, Mich., to Spence Bros., Saginaw. Estimated cost $75,000.

Ice Plant—Southern Ice Co., c/o R. J. Hancock, Pres., Marietta, Ga., will build a 1 stotry ice plant at Austell. Work will be done by owner's forces.

Ice Plants—Southern New England Ice Co., R. G. Hadley, Gen. Mgr., New Britain, Conn., awarded contract for construction of a 1 story, 60 x 120 ft. ice plant on West Main St., New Britain, to Carlson & Torre Co., 805 Main St., New Britain, also 1 story, 60 x 120 ft. plant at Meriden, to Barlett-Brainard Co., 252 Asylum St., Hartford. Estimated cost each $100,000.

Ice Manufacturing Plant — Crystal Ice Co., 101 West Main St., Norwich, Conn., awarded contract for a 1 story, 60 x 90 ft. ice manufacturing plant at Versailles, to John A. Monty, Farnsworth St., New London. Estimated cost $50,000.

Ice Manufacturing Plant—Gladwin & Lane, 224 Elm St., Westfield, Mass., awarded contract for a 1 story, 60 x 100 ft. ice manufacturing plant to L. D. Phillips Construction Co. Inc., 10 Main St., Westfield. Estimated cost $40,000.

Ice Manufacturing Plant—Hygienic Ice Co., 881 State St., New Haven, Conn., awarded contract for a 1 story, 60 x 90 ft. ice manufacturing plant, to Fusco & Amatruda, 59 Amity Road, New Haven. Estimated cost $40,000.

Grain Elevator—Missouri Pacific R.R., Missouri Pacific Bldg., St. Louis, Mo., awarded general contract for workhouse addition to grain elevator including storage bins, 100 ft. high, also repairs and rehabilitation of standing buildings incident to fire damage to Edwin Ahlskog Co., 407 South Dearborn St., Chicago, Ill., and Dwight Bldg., Kansas City, Mo. Sub-contract let for excavating to Winston Bros., 407 Buder Bldg., St. Louis, and foundation piling to A. Whitney & Sons, Inc., 1801 Grand Ave., Kansas City. Hall-Baker Grain Co., Board of Trade Bldg., Kansas City, lessee.

Grain Elevator—Quaker Oats Co., 1025 Howard St., Akron, O., awarded contract for construction of a grain elevator including thirty-six tanks, 124 ft. high and 24 ft. in diameter at Mill and Howard Sts., to James Stewart Corp., 343 South Dearborn St., Chicago, Ill. Estimated cost $275,000. Maturity in August.

Meat Plant—Peter Eckrich, 2506 Broadway, Fort Wayne, Ind., awarded contract for a 1 story, 150 x 200 ft. meat plant to Indiana Engineering & Construction Co., 201 Central Bldg., Fort Wayne. Estimated cost $40,000.

Sausage Plant—Essem Packing Co. Inc., 101 Beacon St., Lawrence, Mass., awarded contract for addition and alterations to sausage plant, to L. C. Cyr, 45 Melrose St., Lawrence. Estimated cost $40,000.

Packing Plant Addition—Sieloff Packing Co., 4329 Natural Bridge Ave., St. Louis, Mo., awarded contract for a 1 story, 40 x 74 ft. addition to packing plant and 1 story, 16 x 94 ft. condenser building at Newstead and Sacramento Sts. to H. A. Haeseler Building & Construction Co., 2346 Palm St., St. Louis. $20,945.

PATENT DIGEST

Baking and Milling

Ice-Cream Cones Made on Automatic Operating Machines — Domenico Antonelli, Manchester, Eng. No. 1,846,018. Feb. 23, 1932.

Paper Cake Cups Fed Mechanically to Baking Pans—Charles G. Steffen, South Jamaica, N. Y., to Dugan Brothers, Inc., Brooklyn, N. Y. No. 1,846,227. Feb. 23, 1932.

Cereal Meal Prepared by Cooking Under Pressure, Mixing With Salt, Drying, Baking, and Grinding to Suitable Fineness—Walter North Boyes, Epson, Auckland, N. Z., No. 1,846,581. Feb. 23, 1932.

Cutter for Doughnut Machine—Frank M. Roehl and Peter J. Toews to National Automatic Doughnut Machinery Co., Minneapolis, Minn. No. 1,846,659. Feb. 23, 1932.

Flour Graded and Collected in Receptacles According to Fineness of Grinding—Karol Berbeka, Lwow, Poland. No. 1,846,783. Feb. 23, 1932.

Dough Divided and Arranged in Pans While Passing Through Machine—Ashley F. Ward and Paul S. Ward to Ashley F. Ward, Inc., Cincinnati, Ohio. No. 1,847,150. March 1, 1932.

Low-Capacity Hand-Operated Doughnut Forming Machine — Charles E. Carpenter, Chicago, Ill. No. 1,847,293. March 1, 1932.

Rotatable Machine for Making Cup or Cone-Shaped Pastry—Oscar Hauge, San Mateo, Calif., to National Biscuit Co., New York, N. Y. No. 1,847,340. March 1, 1932.

Leavening Powder Containing Neutral Pyrophosphate as Filler — Louis Weil, Strasbourg, France. No. 1,847,799. March 1, 1932.

Triangular Shaped Container for Pie Segments—Joseph B. Fisher, Strathmore, Calif. No. 1,848,120. March 8, 1932.

Combination Dough Fermentation Room and Molding Table—Harl C. Simmons, Chicago, Ill. No. 1,848,229. March 8, 1932.

Dairy and Egg Products

Calcium Lactate Recovered From Whey by Making Whey Alkaline, Removing Supernatant Liquid From Precipitate, Washing, and Subsequently Recovering Dissolved Calcium Lactate—John T. Travers to The Ohio Sanitary Engineering Corp., Columbus, Ohio. No. 1,850,643. March 22, 1932.

Skim Milk Used in Lactobacillus Acidophilus Milk Products — Stewart M. Farr, Detroit, Mich. No. 1,851,165. March 29, 1932.

Container for Frozen Confections and Dairy Products — Eric C. Hughes, West Sacramento, Calif., to Popsicle Corp. of the United States, New York, N. Y. No. 1,844,066. Feb. 9, 1932.

Continuous Milk Delivery System for Mechanical Milker—Cyrus Howard Hapgood, Nutley, N. J., to De Laval Separator Co., New York, N. Y. No. 1,844,956. Feb. 16, 1932.

Milk-Can Washing Machine — John P. McKinley, Buffalo, N. Y. No. 1,845,313. Feb. 16, 1932.

Compartmented Receptacle for Receiving and Distributing Milk—Walter H. Paulson to Harry D. Lathrop, Chicago, Ill. No. 1,845,336. Feb. 16, 1932.

Mixture of Sweet Skim Milk and Sweet Buttermilk Cultured by Bacteria, Pasteurized, and Evaporated to Form Stock Food Product—Clay E. Davis to Whatcom County Dairymen's Association, Bellingham, Wash. No. 1,845,961. Feb. 16, 1932.

Objectionable Odors and Flavors Removed From Milk by Aspirator Action—George H. Earman, Harrisonburg, Va., to Nathaniel H. Keezell, Keezletown, Va., as Trustee. No. 1,846,478. Feb. 23, 1932.

Channel Device for Gravity Separation of Whites From Yolks of Eggs—Richard W. Regensburger and Charles T. Walter to Industrial Patents Corp., Chicago, Ill. No. 1,846,754. Feb. 23, 1932.

Butter Blocked and Cut in a Combination Unit—Albert Sharp and George Sharp, Bayonne, N. J. No. 1,848,274. March 8, 1932.

Mechanical Milking Units for Transferring Milk From Teats to Receiver—Cyrus Howard Hapgood, Nutley, N. J., to De Laval Separator Co., New York, N. Y. No. 1,846,805. Feb. 23, 1932.

Milk and Cream Aerated and Cooled During Operation of Cream Separators—William Gordon Gordon-Jones, Punakitere, Bay of Islands, N. Z. No. 1,846,959. Feb. 23, 1932.

Cheese Prepared by Warming Paste of Finely Divided Cheese, Milk, and Rennet Extract to Coagulate Added Milk — Pio Caccia, Chicago, Ill. No. 1,847,210. March 1, 1932.

Unit for Stamping Out and Coating Ice Cream Pies — Millard George Harnden, Seattle, Wash. No. 1,848,250. March 8, 1932.

Chocolate Milk Without Sedimentation Prepared by Using a Cocoa Syrup From Which Solids Have Been Removed by Gravity Separation — Leid D. Zern and Richard C. Munkwitz, College Park, Md., to the Citizens of the U. S. A. No. 1,849,030. March 8, 1932.

Copies of Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Photostatic copies of foreign patents may be obtained at the same address, prices being forwarded on application.

Copies of patents should be ordered by number, as titles used in this digest seldom correspond with title of patent.

Machine for Shaping and Cutting Butter and Other Plastic Materials — John P. Aldrich and Howard A. Morris to the Automat Molding & Folding Co., Toledo, Ohio. No. 1,848,405. March 8, 1932.

Milk Pasteurizer With an Inclined Bottom Wall Fitted With Agitator Operating Vertical to the Plane of the Inclined Bottom—John W. Ladd and Henry B. Williams, Detroit, Mich., to Cherry-Burrell Corp., Chicago, Ill. No. 1,848,957. March 8, 1932.

Fruits and Vegetables

A Rotary-Brush Fruit-Cleaning Machine—Bronson C. Skinner to Florida Citrus Machinery Co., Dunedin, Fla. No. 1,844,264. Feb. 9, 1932.

Dry Fruit Product Consisting of Fruit Juice Solids and Alginate Solid Material—Robert M. Washburn to Albert P. Hunt, Chicago, Ill. No. 1,844,707. Feb. 9, 1932.

Fruit Hand-Cored and Pitted in Unit Machine—Arthur L. Duncan, Piedmont, Calif., to Pacific Machinery Co., San Francisco, Calif. No. 1,847,298. March 1, 1932.

Peanuts Dried and Vined Mechanically—Harold T. Vannah, West Palm Beach, Fla., and Samuel W. Houser, St. Petersburg, Fla., to Brown Co., Berlin, N. H. No. 1,847,318. March 1, 1932.

Concentrated Fruit Syrup Containing Pectin in Suspension; Not in Solution—Robert T. Northcutt to General Packing Corp., Cranford, N. J. No. 1,847,356. March 1, 1932.

Combination Unit for Treating and Subsequently Rubbing Fruit With Liquid Material—Ernest M. Brogden, Pomona, Calif., to Broddex Co., Winterhaven, Fla. No. 1,848,309. March 8, 1932.

Orange Juice Prepared and Processed to Have Standardized Orange Flavor and Color—Walter William Willison, Brooklyn, N. Y. No. 1,848,760. March 8, 1932.

Tomatoes Peeled Mechanically — John Walter Snider, Franklin, Ind. No. 1,825,428. Sept. 29, 1931.

General Equipment

Vertical Type Mixing Machine With Reversible Mixing Units—Herbert L. Johnston to the Hobart Manufacturing Co., Troy, Ohio. No. 1,849,094, March 15, 1932.

Device for Opening Sealcone Containers—Lewis B. Winton, Greenwich, Conn., to American Sealcone Corp., New York, N. Y. No. 1,849,261. March 15, 1932.

Automatic Liquid Weigher Valve Mechanism—Wm. E. Cooper to American Machine & Foundry Co., Brooklyn, N. Y. No. 1,851,348. March 29, 1932.

Machine for Making Bags From Transparent Cellulose Material — Thomas M. Royal, Philadelphia, Pa. No. 1,851,648. March 29, 1932.

Means for Conveying Bottles From Sealing Machine Through Heating Apparatus to Labeling Machine—Charles H. Loew, Avon Lake, Ohio, to Liquid Carbonic Corp., Chicago, Ill. No. 1,852,322. April 5, 1932.

Drum-Type Food Mixing Machine—Amaziah Fillmore Wentworth to Fairmont Canning Co., Fairmont, Minn. No. 1,852,764. April 5, 1932.

Macerating Unit for Pulping and Crushing Food Materials—John Schmidt to Sprague-Sells Corp., Hoopeston, Ill. No. 1,848,225. March 8, 1932.

Storage and Display Case for Frozen Foods—Karl A. Weber, Los Angeles, Calif. No. 1,847,544. March 1, 1932.

Sharp Freezing System for Foodstuffs in Covered Containers Which Pass Under Brine Spray and Through Vat With Brine Flowing in Counter Direction to Passage of Containers—Albert Giger, Vancouver, B. C. No. 1,847,956. March 1, 1932.

Meat Packing

Skins Removed Mechanically From Pork Strips—Walter H. Pruefer, West Barrington, R. I. No. 1,847,536. March 1, 1932.

Sausage Stuffing Machine — Frank B. Anderson to the V. D. Anderson Co., Cleveland, Ohio. No. 1,848,236. March 8, 1932.

Meat Cutting Band Saw—Philip Avilla, Daly City, Calif. No. 1,848,300. March 8, 1932.

Airtight Container for Cooking Meat Into Loaf Form Under Pressure — Gustave F. Kuhn and Henry Janssen, Philadelphia, Pa. No. 1,848,729. March 8, 1932.

Miscellaneous Products and Processes

Juice Extracted From Spent Licorice Roots by Boiling in Weak Ammonia Solution and Pressing With Subsequent Concentrating—Pietro Condorelli and Biagio Antonio Coco, Catania, Italy. No. 1,849,569. March 15, 1932.

Sucrose Produced From Dried Beets—Wm. Kinnear Melrose and John Christopher Stead to Sugar Beet & Crop Driers, Ltd., London, England. No. 1,849,998. March 15, 1932.

Coffee Extracted and Discharged Continuously in Automatic Operating Percolators—Murray A. Medin, Minneapolis, Minn. No. 1,850,082. March 22, 1932.

Vegetable Oil Extracted With Volatile Organic Fat Solvents After Material Is Heated With Dilute Ammonia Solution—Franz Peter Dengler to Lloyd M. Brown, Chicago, Ill. No. 1,850,095. March 22, 1932.

Cereals Given Heat Treatment to Make Change in Starch Content—Wm. G. Anderson, San Francisco, Calif., one-half to M. Clinton Mason, Ross, Calif. No. 1,850,123. March 22, 1932.

Preparation and Handling of Sugar Syrup Containing Invert Sugar—Daniel V. Wadsworth and Leonard Wickenden, Manhasset, N. Y., to John J. Naugle, Greenwich, Conn. No. 1,850,427, March 22, 1932.

Coffee and Cocoa Beans Cleaned by Gravity Separation Using Air Suction—Geo. C. Herz, Flushing, N. Y., to Jabez Burns & Sons, Inc., New York, N. Y. No. 1,850,719. March 22, 1932.

Mixing Machine for Production of Alimentary Pastes — Robert Kölliker, Kollbrunn, Switzerland. No. 1,850,723. March 22, 1932.

Flavor of Roasted Products Developed by Two-Stage Roasting Process — Joseph L. Rosenfield, Alameda, Calif. No. 1,850,971. March 22, 1932.

Nut-Cracking Machine—Edwin Pickett to Blodgett Nut Co., Fayetteville, Ark. No. 1,848,495. March 8, 1932.

Rancid Nut Meats Sweetened by Immersion in NaOh Solution, Subsequently in HCl Solution, Followed by Washing and Drying—Fred Seyer, Vancouver, B. C. No. 1,848,806. March 8, 1932.